MISSISSAUGA

Invasive Species Management Plan

& Implementation Strategy

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1.0 Introduction

1.1 Invasive Species Primer

Invasive species are widely considered to be the second greatest threat to biodiversity after habitat loss (Erlich, 1998; Wilson, 1992). Invasive species are often considered non-native species (but can also be native species) that displace some or most of the native components of a community (White et al., 1993) and negatively impact the function of the ecosystem; including ecosystem services. The impacts of invasive species on ecosystem services have increased awareness about the need to prevent introductions and control established populations.

The most effective way to manage the spread of invasive species is prevention (Anderson et al., 2013; Invasive Species Research Institute, 2013), which is emphasized as a priority of the Ontario Invasive Species Strategic Plan (Ministry of Natural Resources, 2012). Even with the most careful prevention strategies, invasive species can still become established; at which point, a management strategy is required.

Ecosystem services are defined as the benefits provided to society by natural ecosystems (Ministry of Natural Resources, 2009). Ecosystem services as described in the Millennium Ecosystem Assessment (2005) include:

- Provisioning services (i.e., products obtained from ecosystems such as food, freshwater, timber),
- Regulating services (e.g., air quality, climate, flood control, water purification, pollination),
- Cultural services (e.g., recreation/tourism, spiritual/religious values, educational/scientific values, cultural heritage values), and
- Supporting services (e.g., photosynthesis, primary production, nutrient cycling, water cycling, soil formation).

Ecosystem services contribute to human welfare, both directly and indirectly, and therefore represent a significant yet often

Before (left) and after (right) removal of Buckthorn showing drastic changes in aesthetics. Photos by Credit Valley Conservation (CVC).

unaccounted for portion of our economy. A study contracted by the Ministry of Natural Resources in 2009 found the valuation of ecosystem services of representative vegetation cover types in Ontario (e.g., agriculture, forest, open water, wetlands, beach, unvalued terrestrial, aquatic) to be over $84 billion (Spatial Informatics Group, 2009). This valuation is positioned as direct economic provisioning of ecosystem services. That is to say, it does not evaluate cultural and social values associated with natural systems that are important to residents and visitors in Mississauga.

In addition to the cost to ecosystem services, there is a direct economic cost resulting from the impact of invasive species. The Ontario Invasive Species Strategic Plan (Ministry of Natural Resources, 2012) provides the first two examples of costs resulting from invasive species impacts:

- $37 million to cut and replace Ash trees affected by Emerald Ash Borer (*Agrilus planipennis*) (EAB) in the City of Toronto over five years
- $30 million spent up to 2012 by the Canadian Food Inspection Agency (CFIA) to cut Ash trees to slow the spread of EAB

The City of Mississauga has allocated $54.2 million over 12 years beginning in 2013 (City of Missisauga, 2020) to replace Ash trees and remove or treat those affected by EAB. Once invasive species have become established, economic costs associated with managing invasive species varies greatly depending on:

- The species,
- Extent of population, and
- Mechanism used to manage the species.

For example, the cost of controlling Common Reed (*Phragmites australis subsp. australis*) has been cited by the Ministry of Natural Resources and Forestry (MNRF) as between $865 and $1,112 per hectare (Bolton and Brooks, 2010). The ecological cost of not controlling Common Reed (i.e., the 'do nothing' approach) results in:

- A sharp decrease in native plant cover,
- Loss of species richness and biodiversity,
- Alterations of energy availability,
- Changes in nutrient and water cycling,
- Alteration of disturbance regimes and return intervals, and
- Effect on micro-climate (Charles and Dukes, 2007).

Additional impacts include:

- Road hazards,
- Fire hazards,
- Effects on agriculture (loss of economic gains),
- Impact on aesthetics (lake view), and
- Recreational activities (angling, boating, swimming) (Ministry of Natural Resources, 2011).

Urban/suburban wetlands provide ecosystem services amounting to $161,420 per hectare per year (Ministry of Natural Resources, 2009). Common Reed often invades these wetlands inevitably reducing the value of the ecosystem services provided by these wetlands. The ability to increase the ecological, social and cultural value of these wetlands by managing Common Reed will increase the economic value and overall ecosystem services provided by these wetlands, which will far outweigh the costs of managing Common Reed. As such, invasive species management can be considered an investment in improving ecosystem services.

1.2 Federal, Provincial, and Municipal Management of Invasive Species

The federal and provincial governments note the importance of having a well-coordinated invasive species management strategy as is outlined in the national invasive species strategy "An Invasive Alien Species Strategy for Canada"(Environment Canada, 2004) and the Ontario Invasive Species Strategic Plan (Ministry of Natural Resources, 2012).

These strategies recognize first, and most importantly, the need to prevent introductions, followed by early detection and rapid response to early introductions before they become well established and become costly and/or difficult to manage and eradicate. For those species and populations that have already become established and are degrading the ecological integrity[1] of our natural systems, management plans are needed in harmony with a well-coordinated implementation effort. The following describes the roles and responsibilities of governments in managing invasive species in order to identify potential opportunities to engage with federal and provincial stakeholders that may result in efficiencies (i.e. cost savings) and improve management of invasive species within the City.

1.2.1 Federal

Shared responsibilities for the management of agriculture, forests, and wildlife between federal and provincial governments are reflected in arrangements under "An Invasive Alien Species Strategy for Canada". Federal departments have primary roles in prevention, detection, and rapid response as well as in the long-term management of established invasive species.

The CFIA is responsible for the administration and enforcement of acts and regulations regarding the import of potential human health risks as well as threats to natural and agricultural resources.

One of the main pieces of legislation that guides the management of invasive pest species is the Plant Protection Act (S.C. 1990, c. 22), the purpose of which is to "protect plant life and the agricultural and forestry sectors of the Canadian economy by preventing the importation, exportation and spread of pests and by controlling or eradicating pests in Canada". As such, invasive species management in the City of Mississauga's Invasive Species Management Plan and Implementation Strategy (ISMP&IS) considers CFIA regulations and the Plant Protection Act in order to ensure consistency with federal regulations.

1.2.2 Provincial

As the primary landowners and managers of agriculture, forests, freshwater fisheries, and wildlife, provincial governments work with the federal government to help regulate the intentional introductions of alien species on crown and private lands. For example, the government of Ontario contributed to the successful biological control program by supporting the release of three European leaf-eating beetles (to feed on Purple Loosestrife (*Lythrum salicaria*), in an effort to reduce its populations and impact on native plants and wetland function).

The province developed the Invasive Species Act, 2015 (S. O. 2015, c. 22 –Bill 37) which came into force on November 3, 2016.

"The Act provides the power to make regulations prescribing invasive species and classifying them as either prohibited or restricted. A prohibited invasive species is subject to all of the prohibitions in section 7 of the Act unless there are exceptions provided in the regulation. A restricted invasive species is subject only to the prohibitions in subsection 8(1), but may be subject to further restrictions, conditions, prohibitions and measures under the Act if the regulations so provide." (Ministry of Natural Resources and Forestry, 2016)

1 "An ecosystem has integrity when it is deemed characteristic for its natural region, including the composition and abundance of native species and biological communities, rates of change and supporting processes." In plain language, ecosystems have integrity when they have their native components (plants, animals and other organisms) and processes (such as growth and reproduction) intact." (Parks Canada Agency, 2000)

Before (left) and after (right) removal of Ash trees infested with Emerald Ash Borer. Photos by CVC.

The Act identifies Common Reed, Dog Strangling Vine (*Vincetoxicum rossicum v. nigrum*) and Japanese Knotweed (*Fallopia japonica*) as restricted species under the Invasive Species Act, 2015.

The province has also developed the Weed Control Act (R.S.O. 1990, c. W.5). The focus of this Act is to reduce infestations of noxious weeds that negatively impact agriculture and horticulture. Through the Weed Control Act, a noxious weed schedule is established which regulates the destruction, transport, and deposit of these species. The Act also enables regulations to prescribe eradication and prevention measures (e.g., Giant Hogweed (*Heracleum mantegazzianum*)). Landowners whose property contains noxious weeds and weed seeds that negatively affect agricultural lands are responsible for weed control and associated costs.

The province is also involved in ongoing Forest Health monitoring, and provides annual updates on the status and distribution of damaging insects and diseases affecting forests across Ontario (https://www.ontario.ca/page/forest-monitoring#section-5). They can provide expertise and advice on dealing with both native and non-native species of concern to the City of Mississauga.

1.2.3 Municipal

Municipalities play an important role in the management of invasive species on municipal lands. Municipalities have a major role in:

- The detection of new introductions,
- The management of new and established invasive species, and
- The control of noxious vegetation that poses a human health risk.

Co-operation between municipalities and private landowners is vital for successful management activities.

At the Municipal level local bylaws and permitting requirements can aid in managing the introduction and spread of invasive species. Tools available at the municipal level include bylaws under various sections of the Municipal Act. For example, the City of Mississauga By-law Number 0267-2003 prescribes standards for maintenance of nuisance weeds (e.g., European Buckthorn and Garlic Mustard) on private lands: “Every owner of land shall destroy and remove all nuisance weeds and weed seeds on their lands”.

1.3 Invasive Species in the City of Mississauga

The City of Mississauga’s Natural Heritage System (NHS) and Urban Forest[2] provide a critical role in sustaining the City’s green infrastructure by providing numerous ecosystem services and

2 The Urban Forest means all the trees in the City, including those within and outside of the Natural Heritage System, and on public and private lands, as per the Mississauga Official Plan List of Definitions 19, as well as the soils that sustain them. (City of Mississauga Official Plan Chapter 6, Policy 6.3).

serving as a natural space for the City's residents to enjoy. The ecosystem services and health benefits provided by the urban green spaces (e.g., woodlands, wetlands, meadows and trees located throughout the City) directly benefit human health and well-being. Ecosystem services include:

- Climate change mitigation,
- Community benefits and services (e.g., supporting active living),
- Economic benefits and services (e.g., decreased heating and cooling costs), and
- Physical and mental health services such as stress reduction.

These green spaces are the natural and cultural heritage features that bring together the residents of the City by providing a shared resource that connects the City of Mississauga's past, present, and future. Invasive species are widespread in the City's natural areas[3] and have become a major threat to the ecological integrity of the City's Natural Heritage System and the Urban Forest canopy (Urban Forest Management Plan Consulting Team, 2014). For the purposes of this report, invasive species include terrestrial plants (including wetland plants and excluding aquatic plants) and insects as these currently pose the greatest threat to the ecological integrity of natural spaces and the Urban Forest canopy of the City. Invasive fauna shall include insect species that are considered to be invasive forest 'pests' (native or alien).

The ecological effects of invasive species can be irreversible and extremely difficult to control or eradicate once established. Invasive flora, including Garlic Mustard (*Alliaria petiolata*), European Buckthorn (*Rhamnus cathartica*), and Dog-strangling Vine (*Vincetoxicum rossicum, V. nigrum*), are prevalent in portions of certain natural areas within the City, and pose a threat to native biodiversity. Invasive fauna including EAB, Gypsy Moth (*Lymantria dispar v. dispar*), and Asian Long-horned Beetle (*Anoplophora glapripennis*) (ALHB) are impacting the City's natural areas, thereby altering the vegetation structure and ecosystem dynamics in a way that benefits the establishment and spread of non-native

3 Natural Areas are defined in the Mississauga Official Plan as "... natural areas (e.g., meadows, fish and wildlife habitats), woodlands, wetlands and valley and watercourse corridors. These areas represent the pre-settlement landscape, remnant parcels of native vegetation and areas that have been restored to a natural state through naturalization or successional growth (Chapter 6, part of Policy 6.3). Natural Areas are identified within the plan based on Environmental Significance, Floristic Quality/Co-efficient, characteristics of woodlands, presence of Species at Risk, characteristics of wetlands, watercourses, and/or lakes. For more details, please consult the Mississauga Official Plan and the Natural Areas Survey.

Before (left) and after (right) removal of Dog-strangling Vine from a forested area where it dominated the understory. Photos by CVC.

invasive plant species. This is currently occurring in the understory of woodlands where Ash trees are dying or being removed due to infestation with EAB. Where the understory has an established population of non-native invasive plants, such as Buckthorn and Garlic Mustard, the opening of the canopy will result in rapid growth and opportunities for spread of these aggressive species which end up outcompeting native species, such as oaks and maples. This provides an example of the urgency to manage invasive species, particularly while there are areas currently being managed through the removal of Ash trees affected by EAB.

The City is currently managing several plant and insect invasive species (e.g., Gypsy Moth, EAB, and Giant Hogweed). However, the City has not previously had an integrated and comprehensive City-wide approach for managing terrestrial invasive plant and insect species. The City has management plans for specific targeted species; however, the approach used to address other invasive species (e.g., Garlic Mustard and European Buckthorn) has often been site specific, or in response to requests or initiatives from stewardship groups. Therefore, the 2014 Urban Forest Management Plan (UFMP) recognized the need to develop a proactive and comprehensive invasive species management plan for the City that provides an over-arching City-wide approach to management of invasive flora and fauna.

The City of Mississauga recognizes the need to develop a comprehensive Invasive Species Management Plan and Implementation Strategy (ISMP&IS) that balances the ecological, economic, and social vision for the City while working towards better protecting and enhancing the City's natural resources. In the early development stages of the ISMP&IS, a Background Analysis Report (North-South Environmental Inc., 2016) was prepared that provides a comprehensive review of current practices for managing invasive species and to identify priority species and natural areas on which the City can focus resources in order to maximize results. Many components of the ISMP&IS are based on the Background Analysis report and revisions have been made over time based on new information available and professional knowledge. The ISMP&IS is intended to be adaptive and will continue to be updated as needed to ensure the ISMP&IS is up-to-date and uses the best management practices available. The Background Analysis Report (North-South Environmental Inc., 2016) (Appendix 1) provided criteria and considerations for selecting priority invasive species for management (Table 1) within the City's natural areas and the top 10 natural areas for management (Table 2). As identified in the Background Analysis Report, the priority species list requires review and revision on a regular basis and management priorities should be adapted as required. Accordingly, the species list has been updated to include additional priority species and priority subcategories.

Priority species have been assigned into two subcategories based on the threat they pose to the City's NHS and the anticipated management objectives for each. As part of the early detection and rapid response framework, management may be required in non-priority sites to prevent populations from becoming established. Accordingly,

- Priority 1 species will be managed in all natural areas across the City, with a focus on ISMP priority sites.
- Priority 2 species will be managed only at the ISMP priority sites (Table 2) and demonstration sites (Section 12).

Other invasive species that are not considered priority species will be considered for control only where their removal will support the future restoration and success of a particular project.

Table 1. Priority invasive species for management within the City's natural areas. Priority levels are as follows: (1) species will be managed in all natural areas across the City, with a focus on ISMP priority sites and (2) species will be managed only at the ISMP priority sites and demonstration sites.

Scientific Name	Common Name
Flora: Priority 1 species	
Ailanthus altissima	Tree-of-heaven
Vincetoxicum rossicum, V. nigrum	Dog-strangling Vine
Heracleum mantegazzianum	Giant Hogweed
Pastinaca sativa	Wild Parsnip
Flora: Priority 2 species	
Acer negundo	Manitoba Maple
Acer platanoides	Norway Maple
Aegopodium podagraria	Goutweed
Alliaria petiolata	Garlic Mustard
Alnus glutinosa	European Alder
Celastrus orbiculatus	Oriental Bittersweet
Convallaria majalis	Lily-of-the-valley
Elaeagnus angustifolia *E. umbellata*	Russian Olive Autumn Olive
Euonymus alatus *E. europaeus* *E. fortunei*	Non-native Euonymus
Ficaria verna	Fig buttercup
Hedera helix	English Ivy
Impatiens glandulifera	Himalayan Balsam
Lonicera japonica *L. maakii* *L. morrowii* *L. tatarica, L. x belli* *L. xylosteum*	Non-native Honeysuckles
Morus alba	White Mulberry
Reynoutria japonica	Japanese Knotweed
Robinia pseudoacacia	Black Locust
Phragmites australis	Common Reed
Rhamnus cathartica	European Buckthorn
Frangula alnus	Glossy Buckthorn
Viburnum opulus	Guelder Rose
Vinca major *V. minor*	Greater Periwinkle Common Periwinkle
Fauna: Priority 1 species	
Agrilus planipennis	Emerald Ash Borer
Anoplophora glabripennis	Asian Long-horned Beetle*
Lymantria dispar	Gypsy Moth

**Asian Long-horned Beetle has been eradicated from Mississauga however should be considered a priority should populations recur.*

Table 2. High priority natural areas for invasive species management as determined through the Background Analysis Report (North-South Environmental Inc., 2016).

Rank	Natural Area Name	Natural Area Code
1	Riverwood	CRR10
2	Erindale	CRR6
3	Cawthra Woods	LV7
4	Sawmill Valley Trail	EM4
5	Tecumseh	CL24
6	Meadowvale Station Woods	MV2
7	Credit Meadows	CRR2
8	Britannia Woods	HO9
9	Hewick Meadow	CRR11
10	Lisgar Meadow Brook - Swamp Maple Mineral Deciduous Swamp Type (SWD3-3)	LS1

2.0 Goals, Targets and Timelines

With any long-term management plan, it is critical to set clear goals, targets, establish realistic timelines, and track the implementation of the ISMP. It is recognized that significant resources will be required to manage invasive species at a city-wide scale. The effective implementation of the ISMP will improve the efficiency with which these resources are allocated.

2.1 Goals and Objectives

The ISMP&IS takes into consideration the complex issues surrounding invasive species including the need for a long-term multi-faceted strategy. Efforts to manage invasive species are most effective when:

1. Focused on clearly defined, measurable goals,
2. Based on current biological and socio-economic information,
3. Benefit a diversity of stakeholders, and
4. Integrated across all spatial and temporal scales.

Goals and objectives provide the central focus for successful invasive species management; they identify and focus management priorities, provide a context for decision making, guide adaptive management, and offer a defensible link among management direction (e.g., the City's Natural Heritage and Urban Forest Strategy (North-South Environmental Inc., 2014), the City's Official Plan policy to "protect, enhance, restore and expand the Natural Areas System" (Policy 6.1.1, City of Mississauga, 2015), and Federal and Provincial Strategies and Legislation, as discussed in Section 1.2 of this report).

The goal of the ISMP&IS is to provide an organized targeted approach to managing terrestrial invasive species in an economically efficient manner while enhancing native biodiversity and overall ecological integrity of the City's natural areas.

The broad objectives of the ISMP&IS are to:

1. Reduce the relative abundance of invasive species and increase ecological integrity,
2. Optimize resources through collaboration with partners and the public, and
3. Monitor the effectiveness of ISMP&IS.

2.2 Targets and Timelines

Developing measurable and achievable targets will allow the City to assess the progress of meeting the ISMP&IS objectives. Based on discussion with City partners, experts and practitioners, the following targets upon which to evaluate the success of invasive species management have been established:

1. Project/location specific target of 85% reduction in the population of invasive plants.
2. Priority natural area specific target of 50% reduction in the population of invasive plants throughout the natural area.
3. For priority fauna species: stay within threshold levels as established by specific Integrated Pest Management (IPM) programs.

Additional targets related to optimizing resources and monitoring invasive species populations have been provided. These targets should be re-evaluated throughout the implementation of the ISMP&IS and refocused through a progress report prepared at the end of each control period (approximately five years). The purpose of the progress report will be to update priority species and sites, identify additional techniques for management of invasive species, and identify lessons learned to inform an adaptive management approach. Recommendations identified in the progress report for improving management of invasive species should then be incorporated into the Management Plan.

Table 3 identifies objectives, actions, targets, and timelines to track the progress of the ISMP&IS.

2.3 Tracking of ISMP&IS Progress Report

Implementing an invasive species management plan for the City of Mississauga is a large undertaking that will contribute to enhancing the ecological integrity of the City's natural areas. Tracking of the ISMP&IS is critical to ensuring resources are being optimized and City staff can account for all management activities, while adapting management decisions to changes in priority species and sites. As part of tracking the development of the ISMP&IS, summary reports should be completed annually for each site managed. Additionally, progress reports should be created upon the completion of management of each site. The progress report may include the following information:

- List of natural areas managed
- Invasive species identified through baseline inventory for each natural area
- Management activities undertaken in each natural area
- Cost of management, both estimated and actual
- Funding/grants applied for and awarded
- Partners identified and engaged in management of natural area
- Community outreach initiatives, educational directives
- Volunteer opportunities identified and engagement activities
- Results of monitoring post management activity

Appendix 2 provides a template for tracking the progress of management initiatives and activities undertaken as part of the ISMP&IS. This template can be used either in a spreadsheet (e.g., MS Excel) or a database program (e.g., MS Access) that will permit better organizing, analysis, storage of data from inventory and monitoring field work, and production of tables for inclusion in the progress report.

Table 3. Summary of objectives, actions, targets, and timelines.

Objectives	Action	Target	Timeline
Reduce abundance of invasive plant species	Implement management in two (2) demonstration sites	By project[1]: 85% reduction in abundance of priority invasive plant species	Approximately 5 years or until targets are achieved
		By demonstration site: 80% reduction in abundance of priority invasive plant species	
	Implement management in first five (5) priority sites	By project: 85% reduction in abundance of priority invasive plant species	Approximately 5 years or until targets are achieved
		By priority site: 50% reduction in abundance of priority invasive plant species	
	Implement management in remaining five (5) priority sites	By project: 85% reduction in abundance of priority invasive plant species	Approximately 5 years or until targets are achieved
		By priority site: 50% reduction in abundance of priority invasive plant species	
Stay within threshold levels for priority invasive insects	Use Integrated Pest Management, decision matrices, and provincial/federal guidance to support the control and/or eradication of invasive insects	For priority species: stay within threshold levels as established by IPM	On-going
Optimize limited resources	Collaborate with partners to share knowledge and resources	Engage at least one partner to assist with implementation of management	During first year of management per site
	Engage with the public through education and volunteer opportunities	• Inform community in immediate area of priority sites area of proposed management activities • Provide one workshop per year (strategic timing to maximize attendance e.g., evenings, spring/early summer) • Coordinate volunteer action day in priority sites	During first year of management per site
	Submit applications to receive funding/grants	Submit at least one grant/funding application	TBD based on specific funding/ grant agency
	Complete Progress Reports	Summarize financial costs associated with management activities through: 1. Annual summary reports for each site controlled that year 2. Progress reports to coincide with control periods for demo sites and priority sites	1. Annually 2. Approximately 5 years or until targets are achieved
	Review and update resource allocation based on current priorities and funding	Target resources to meet timelines associated with implementation of demonstration and priority sites	Annually
Monitoring of priority sites	Complete baseline inventory of priority sites	Baseline inventory of invasive species along trails and through high-quality vegetation communities	Prior to commencing management activities
	Complete monitoring of priority sites post management activity	100% of all managed locations monitored	Within two years of management activity
	Complete progress reports	Summarize work progress associated with management activities through: 1. Annual summary reports for each site controlled that year 2. Progress reports to coincide with control periods for demo sites and priority sites	1. Annually 2. Approximately 5 years or until targets are achieved

1 Where "Project" represents a targeted and specific management action that has been applied (e.g., Japanese Knotweed removal from sensitive vegetation community within a pilot site, Garlic Mustard removal from forested area).

3.0 Methods and Criteria for Prioritizing Resource Allocation

One of the most restrictive aspects to invasive species management is resource allocation, both financial and staffing. A process whereby efficient use of resources can be determined is essential to make the best use of funds available for invasive species management. The steps to determine resource allocation are as follows:

1. Determine aim and scope
2. Budget review
3. Form an Internal Working Group
4. Determine decision making criteria
5. Internal Working Group identifies options, comments, and makes recommendations

These steps are discussed in further detail in Sections 3.1 to 3.5. It is suggested that these steps be completed annually, or upon receipt of additional resources.

3.1 Determine Purpose and Scope

The purpose of the ISMP&IS is to manage the population of priority invasive species (Table 1) in priority natural areas within the City (determined through Background Analysis report (North-South Environmental Inc., 2016). A target must be established to determine if there has been success in achieving the objective (Table 1). This target requires monitoring before and after management activities have occurred. Through monitoring the City will be able to determine whether the objective has been reached in a particular area, or whether continued management will be required.

The focus of invasive species management is on high quality natural areas, that typically contain a high relative abundance (and often diversity) of native flora, with a higher degree of ecological function and resiliency. Generally, high quality areas have a greater potential to be more resistant to invasion.

Reviewing and prioritizing resource allocation should be completed annually by City staff in order to respond to information gathered through monitoring of natural areas. Priorities and schedules should be based on revised budgets, a change in priorities/direction from council, and other changes that can occur over time. The following sections outline the steps to be taken annually (Sections 3.2 to 3.5).

3.2 Review Budget

It is essential to review existing budgets for work to be completed, including current activities and expenditures, to determine the budget available to complete invasive species management. Knowing existing budgets will allow projects to be scoped, or identify the need for additional resources, partnerships and/or other funding sources to complete the desired projects.

The City's current budget for invasive species management has not yet been determined. The budget should take into consideration the costs associated with existing management

programs for invasive insects (Gypsy Moth, ALHB, and EAB) and noxious plants (Giant Hogweed).

It is recommended that following 3-5 years of management at the two demonstration sites (Section 12), the sites be showcased to demonstrate progress and success with the program. The experience gained during this time can be used to inform the budget, as such the budget should be reviewed at that point.

3.3 Form Internal Working Group

An Internal Working group will be responsible for making decisions as to the allocation of available resources. This working group should be made up of City staff from departments involved in natural areas management (e.g., Parks & Forestry) in order to provide a number of perspectives and achieve a comprehensive approach to resource allocation for invasive species management.

3.4 Determine Decision Making Criteria

Decision making criteria primarily pertains to determining which natural area(s) to manage each year, and where to manage within each of the chosen natural area(s). Therefore, the decision making criteria can be grouped into two categories:

- Between natural areas, and
- Within natural areas.

3.4.1 Decisions Between Natural Areas

Criteria for decision making between sites will help inform which site(s) to manage in a given year. While these decisions will be made primarily from an ecological perspective it is important to take into consideration opportunities to optimize available resources. The ranked priority natural area list from the Background Analysis Report (Section 5.3, North-South Environmental Inc., 2016) has already taken into account the ecological considerations. The sequence of priority sites (Table 4) is based on the quality of the site (as determined through the Mississauga Invasive Species Management Plan Background Analysis Report (North-South Environmental, 2016), with the highest quality sites at the top of the list.

To inform decisions on selecting which priority site where management should take place, it is recommended that the following additional considerations be reviewed:

- Staff and equipment efficiencies (e.g., combine invasive species management with other work in natural areas, such as hazard tree removals) in order to maximize resources by using staff and equipment while on site
- Being opportunistic with volunteer or partnership opportunities (e.g., if a Conservation Authority is working in a priority natural area, partnering with them on that project would decrease City budget requirements); and,
- Accessibility for vehicles (e.g., sites or areas within a site that are more easily accessible for vehicles are generally more cost effective for management rather than using extra time and staff resources to move materials and equipment to the management site within the natural area)
- Characteristics and populations of invasive species present at sites (i.e. first address priority species in isolated or small populations to prevent expansion or establishment of satellite populations)

Table 4 evaluates the 10 priority sites based on the considerations for optimizing resources as described above. The site with more opportunities to maximize resources may be prioritized over a site which has a higher rank from an ecological perspective. There may be additional considerations for optimizing resources that have not been included in the examples provided above that should be used to inform decisions on where to manage. Furthermore, ongoing projects and volunteer opportunities may change. As

such, this table should be considered a working table that can be reviewed and revised on an annual basis in order to account for changes to available resources and current management activities.

3.4.2 Decisions within Natural Areas

High Quality Vegetation Communities

High Quality Vegetation Communities typically contain a high relative abundance (and often diversity) of native flora, with a higher degree of ecological function and resiliency. Generally, high quality vegetation communities have a greater potential to be more resistant to invasion.

Furthermore, these areas typically contain a relatively low abundance of invasive species that are often found in smaller, isolated populations (i.e. satellite populations), as opposed to patchy, dense and widespread colonies (see Section 6.1.1 for discussion spatial extents and distribution, and an illustration). Managing satellite populations is a common practice in invasive species management as this allows for quicker/easier control of invasive populations before they become established in an area and more costly/timely to control and remove.

High quality vegetation communities within natural areas should be a starting point for completing inventories. High quality vegetation communities, as classified according to Ecological Land Classification (ELC) for Southern Ontario (Lee et al., 1998), can be grouped into the following community classes:

- Forests (FO)
  - Deciduous (FOD)
  - Coniferous (FOC)
  - Mixed (FOM)
- Wetlands
  - Swamp (SW)
  - Marsh (MA)
  - Shallow Aquatic (SA)

These forest and wetland classes are generally considered to be of higher quality than cultural communities (woodland (CUW), plantation (CUP), savannah (CUS), thicket (CUT) and meadow (CUM), which are typically characterized by more recent disturbance that has led to its earlier successional state and a higher abundance of non-native species which are more adaptable and quickly colonize disturbed sites. However, several

Table 4. Decision matrix for identifying priority sites for resource allocation.

Natural Area Name	Natural Area Code	Types of Resource Efficiency		
		Other Projects Occurring	Volunteer and Partnership Opportunities	Vehicle Accessible
Riverwood	CRR10	X	X	X
Erindale	CRR6			X
Cawthra Woods	LV7		X	X
Sawmill Valley Trail	EM4			partial
Tecumseh	CL24	X		
Meadowvale Station Woods	MV2		X	partial
Credit Meadows	CRR2			
Britannia Woods	HO9	X	X	
Hewick Meadow	CRR11	X		X
Lisgar Meadow Brook Section including Swamp Mineral Maple Deciduous Swamp Type (SWD3-3)	LS1		X	X

forest and wetland communities are typically comprised of a higher abundance of non-native plants, such as some lowland (FOD7) and upland forests (FOD4), and wetland communities (e.g., meadow marsh dominated by Common Reed) that have experienced more recent disturbance. Excluded from the high quality category are aquatic communities (e.g., open and submerged aquatic) as this Management Plan focuses on terrestrial and wetland communities.

The focus on higher quality vegetation communities will ensure the ecological integrity in these areas is maintained and enhanced through the invasive species management effort. A list of higher quality ELC community ecosites is provided in Appendix 3. It should be noted that this list is based on surveys and inventories completed to date, and should be updated when future surveys identify additional high quality vegetation communities. It is recommended that these ELC communities be identified within natural areas selected for management as potential higher quality areas to focus baseline inventory efforts. Although the focus is on high quality vegetation communities, inventories should also take note of seed sources of invasive plants, such as from adjacent vegetation communities. The initial effort for invasive plant management would be in the high quality vegetation communities, with a secondary focus on removing the potential sources of those invasive plants from adjacent vegetation communities.

Rare Vegetation Communities

A second consideration for making decisions for resource allocation within natural areas is the presence of a significant vegetation community (see Glossary in Appendix 9 for definition) / rare vegetation types (i.e. ranked G1, G2, G3, S1, S2 or S3). Due to the rare occurrence of these vegetation communities, protecting them from the impacts of invasive species should be a priority when determining where management should occur. Currently, the following rare vegetation community types (according to NHIC) have been identified in the City of Mississauga through a review of the City's Natural Area Survey:

- Fresh-moist bur oak deciduous forest – S2S3
- Dry-fresh oak-hickory deciduous forest – S3S4
- Fresh-moist shagbark hickory deciduous forest – S3S4
- Fresh-moist black walnut lowland deciduous forest – S2S3
- Dry tallgrass prairie – S1

Species at Risk

A third consideration for making decisions for resource allocation within natural areas is the presence of Species at Risk (SAR) and significant species (see Glossary in Appendix 9 for definition) / provincially rare species within a natural area. The presence of SAR and provincially rare species within the City's natural areas is identified through the City of Mississauga's Natural Areas Survey (NAS); however, specific species locations of rare species are often unknown. Management efforts could target SAR and rare species habitats, should they exist on site, using species-specific knowledge of the species' habitat requirements. Invasive species management activities are generally regarded as a benefit and improvement to SAR habitat; however, prior to working in SAR habitat, discussions will need to be carried out with the Ministry of Environment, Conservation and Parks (MECP) to ensure that the planned activities are permitted. An additional benefit of working in SAR habitat is that funding is often available for projects that create a benefit to SAR. Funding sources are further discussed in Section 11.

Existing Invasive Species Population

A fourth consideration for making decisions for resource allocation within natural areas is the presence of existing invasive species populations. Once the baseline inventory of priority invasive species populations has been completed within a natural area, an analysis must be completed to determine which invasive species

or areas should be managed first to ensure appropriate resource allocation. Considerations for allocating resources for priority invasive species within a natural area include:

- Spatial extent: Begin with satellite populations before larger established populations that are more costly and difficult to manage
- Management approach and technique: Management approaches and techniques vary between species and vegetation form and therefore costs vary (e.g., woody vs. herbaceous species, contractors vs. City staff and volunteer effort)
- Opportunistic: Combine activities to optimize resources (e.g., look for opportunities to pair invasive species management with other on-site activity)
- Access: Sites with vehicle access or trails leading to existing populations will increase ease of equipment and material transport.

Considerations for which species and areas to target, including a decision matrix, are described in detail in Sections 6 and 7.

3.5 Internal Working Group Review of Options and Recommendations

Based on the options that arise from the considerations in Section 3.4, the Internal Working group can comment and discuss the sites identified. Often, there will be additional factors that cannot be captured by criteria that may come into consideration when prioritizing resources (e.g., council direction, community interest/ preference). From this review, the final decisions for resource allocation can be made with consideration of all available information.

4.0 Opportunities for Engagement

4.1 Partnership Opportunities

Effective invasive species management depends on community engagement, inter- and intra-specific collaboration, and developing partnerships. Organizations that present partnership opportunities that can contribute to the successful execution of the ISMP&IS for the City of Mississauga include neighbouring and Regional municipalities, Conservation Authorities, non-profit and community groups, educational institutions, businesses, utilities, government agencies, and other City departments.

The City's partners can bring valuable knowledge, expertise and resources that can be used to improve the success of the ISMP&IS. Such knowledge, expertise, and resources can be described in seven categories, as displayed in Table 5. A matrix of organizations and the potential partnership opportunities that exist for the City are identified in Table 6.

4.2 Public Engagement, Outreach, and Education Opportunities

The local community can be a major asset and champion in the efforts to manage invasive species throughout the City of Mississauga, as residents are often stewards of the natural spaces that are found in their communities. By providing opportunities for education and community involvement in invasive species management, the City can instill a deeper sense of community and belonging in its residents, and realize tangible invasive species management benefits.

Public engagement, outreach, and education can involve tasks including:

- Developing educational materials (e.g., interpretive signage, pamphlets, brochures, training modules);
- Reaching out to the public through social media and networking with partnering agencies;
- Engaging the public in community events such as guided field trips or basic invasive species control activities; and
- Organizing and facilitating workshops.

Young volunteer pulling Garlic Mustard. Photo by CVC.

The items listed in Table 7 provide an opportunity to engage the public in a way that is highly relatable and easily accessible. This table identifies the following opportunities:

- Proactive outreach and education,
- Provide readily available resources such as existing information pamphlets (e.g., pamphlets available through the Canadian Food Inspection Agency, the Invasive Species Centre and the Ontario Invasive Plant Council).
- Build and draw from existing programs
- Provide signage in natural areas for on-site outreach,

education, and engagement

- Use of social media to engage residents in a readily-available medium

4.3 Opportunities for Public Participation with Safe Techniques

Consideration should be given to public safety and identifying which invasive species management strategies are suitable for public engagement (e.g., plants that are easy to identify and simple to remove such as Garlic Mustard) and which are not (e.g., noxious plants such as Giant Hogweed would not be suitable due to phototoxic properties). Providing a forum and opportunities for safe and accessible public engagement, education and outreach is a critical component of an inclusive process that will increase community acceptance and involvement in invasive species management.

Volunteers may be more interested in fun activities that offer an immediate reward (e.g., seeing garbage bags full of their efforts), where they can include family members of varying ages, and activities that do not require their own resources. However, there may be opportunities to engage a group of volunteers who are interested in forming an 'invasive plant working crew' that are trained in more complex methods for invasive species management, similar to a 'trail maintenance crew' that may work to improve trails. An approach that has been taken with some other organizations is to encourage "Volunteer Leaders"; individuals that have more responsibility, can lead events, and represent the City without staff being present. Additional training requirements would be necessary to qualify these individuals for this type of role.

Considerations for public participation:

- Timing (e.g., time between contractor spraying and public Garlic Mustard pulls, effective time for controlling plant, engaging volunteers outside of key vacation months/ holidays)
- Ability (e.g., hand pulling of an easily-identifiable species, level of training/experience of participants - if you have

Himalayan Balsam (left) and Garlic Mustard (right) are easy to pull by hand, making them suitable for public invasive species removal events. Photos by CVC.

knowledgeable volunteers/individuals in a volunteer group, engage them in a more advanced activity to keep them interested and use their abilities to the greatest capacity

- Health and Safety (e.g., no contact with toxic materials (plant or herbicidal), avoidance of work on steep slopes, water hazards, working alone)
- Accessibility (e.g., sites easily accessible; generally flat areas are best for a wide range of groups)
- Presence of high quality native plants that could be destroyed by trampling or piling materials
- Aesthetic impact (e.g., volunteers likely interested in projects where they can see a visual impact from work done at the end of the day)
- Space to make piles of invasive species biomass removed from the natural area materials
- Future planned restoration work (opportunity for volunteers to gain a vested interest in the site and return for restoration work after invasive species are removed)

General activities suitable for public participation include those that are accessible, straight-forward, low-impact, minimal tools required, can be individual or group activity, minimal guidance, limit the use of power tools, those that are high visual reward/ immediate satisfaction, and those that contribute to a locally-based conservation ethic. For example,

- Hand pulling or digging
- Tarping
- Girdling
- Smothering invasive plants (e.g., wood chip layer, brush pile) and follow up with hand pulling newly emerged stems
- Extractigator® for Buckthorn, non-native Honeysuckle (Lonicera), and saplings or small trees
- Monitoring for presence of invasive species or regrowth in managed areas
- Cutting small trees (i.e., <4 m in height) and shrubs, so paid crews can then treat stumps with herbicide

Table 5. Opportunities presented through partnership.

Opportunity	Description
Coordinate Efforts	Opportunities to coordinate efforts of invasive species management across municipal and watershed boundaries to ensure a consistent approach. Opportunities to coordinate efforts within the City on Conservation Authority or Regionally-owned properties
Cost Sharing	On jointly-owned/managed properties, there may be opportunities to share costs on projects that are mutually beneficial to all parties
Species Information	Opportunity to learn of invasive species movements, potential new species to the area, and novel successful management approaches.
Existing Programs	Programs may exist with these groups and there may be opportunities to partner on, and learn from, such programs
Volunteer Sources	Existing volunteer sources could be drawn upon to complete management projects
Education Materials	Educational materials, including species-specific pamphlets, may be available from partner groups
Survey Equipment	Novel and/or cost-prohibitive survey equipment may be shared between partners for surveying/ mapping invasive species populations
Prevention	Opportunity to reach broader audience through network of collaborators and supporting organizations/businesses. Within the City, leverage planning and engineering departments with respect to Best Management Practices (BMPs), reporting, and review (e.g., input to planting plans)

Table 6. Opportunities that exist for partnership on invasive species management projects within the City of Mississauga.

Group	Agency/Organization	Coordinate Efforts	Cost Sharing	Species Information	Existing Programs	Volunteer Sources	Education Materials	Survey Equipment	Prevention
Neighbouring and Regional Municipalities	• Brampton • Milton • Oakville • Peel Region • Toronto	X		X		X	X		X
Conservation Authority	• Conservation Halton (CH) • Credit Valley Conservation (CVC) • Toronto and Region Conservation (TRCA)	X	X	X	X	X	X		X
Non-profit and Community Groups	• Association for Canadian Educational Resources (ACER) • Evergreen • Halton Charitable Council • LEAF • Ontario Early Detection Rapid Response (EDRR) • Ontario Federation of Anglers and Hunters (OFAH) • Ontario Invasive Plant Council (OIPC) • Ontario Invasive Species Awareness Program (OISAP) • Protect Our Water and Environmental Resources (POWER) • Society for Ecological Restoration in Ontario (SERO) • South Peel Naturalists • Halton/North Peel Naturalist Club • The Riverwood Conservancy • Ecosource		X	X	X	X	X	X*	X
Educational Institutions	• Sheridan College • University of Toronto Mississauga (UTM) • University of Toronto • Peel District School Board (Elementary and Secondary) • Peel Catholic District School Board • Private Schools					X	X	X	

Group	Agency/Organization	Coordinate Efforts	Cost Sharing	Species Information	Existing Programs	Volunteer Sources	Education Materials	Survey Equipment	Prevention
Business, Utility and Government Agency	• Canadian Food Inspection Agency • CP Railway • Greater Toronto Airport Authority (GTAA) • Hydro One Networks Inc. • Infrastructure Ontario • Ministry of Natural Resources and Forestry (MNRF) • Ontario Power Generation (OPG) • Metrolinx	X					X		
City Departments	• Community Services: – Parks, Forestry & Environment – Recreation – Culture • Corporate Services: – Facilities and Property Management • Planning and Building: – Building – Policy Planning • Transportation and Works – Engineering and Works – Transportation and Infrastructure Planning	X	X			X		X	X

Some volunteers may have the knowledge and previous experience (e.g., landscaper, ecologist, arborist) that will allow them to have a greater contribution. These more experienced volunteers should be encouraged to apply their skills in order to increase the success of the invasive species control efforts and allow them to feel their contribution is meaningful. Likewise, it is important to recognize that unexperienced volunteers and children play an important role, but will require greater guidance and supervision.

Characteristics of species suitable for public participation:

- Non-toxic,
- Can be managed using techniques suitable for public participation,
- Trained and experienced volunteers can work with species that are more challenging to identify, or in areas where there are higher quality plants surrounding the invasive plant population, as there is less chance of losses and mistakes, and
- Less experienced volunteers and children can work with easily distinguishable species with some training and supervision.

Table 7. Opportunities for public engagement, outreach, and education.

Opportunities	Details
Proactive Activities	• Promote the Grow Me Instead program to discourage the use of invasive species in garden plantings • Work with nurseries to promote native plant species • Work with OIPC, TRCA, CVC, and others to support programs • Encourage phasing out invasive plant sales at nurseries (supported by Invasive Species Act 2014) • Promote native plant sales by North American Native Plant Society, which occur every Spring • Continue Seedy Saturdays in Mississauga, which provides a forum for invasive species education and outreach through gardening workshops, and seed exchanges • Look for opportunities to conduct open houses, workshops, presentations • Implement a "train the trainer" strategy for independent volunteer opportunities • Determine appropriate/supported reporting mechanism by the public • Develop a list of volunteer opportunities in Better Impact Software
Documents	• Use buzz words such as "alien", "invaders", "biodiversity", and "ecosystem services" to grab attention. Link buzz words to invasive species impacts and the need for management • Species-specific pamphlets are available from the Invasive Species Awareness Program (Ontario Federation of Anglers and Hunters), Ontario Invasive Plant Council, Invasive Species Centre
Existing Programs	• The City's One Million Trees program has an existing volunteer base and workshops for members; a potential source for invasive species management volunteers. • Work with partners on their existing programs in City's natural areas (e.g., CVC's "Your Green Yard" which has programs, workshops, factsheets, and other information)
Signage	• Demonstration project sites interpretive signage, project-specifics, City's approach, common invasive species for priority sites (e.g., Buckthorn, Garlic Mustard, Dog-strangling Vine, Japanese Knotweed), public role, reporting • Update to City signage to improve understanding at priority sites • Trailhead and educational signs should include a hotline number (311) and Early Detection & Distribution Mapping System (EDDMapS) (website/app) details for reporting invasive species observations
Social Media	• Post volunteer activities and information about invasive species on social media outlets (e.g., Pingstreet, Instagram, Facebook, Youtube, Twitter) • Tie in with national events (e.g., Invasive Species Awareness Week) • Re-post/follow other organizations' (e.g., OIPC, OFAH) social media feeds • Post photos and information about events and workshops • Twitter chat on the topic of invasive species • Short (1 min) videos for each priority invasive species and each priority natural area to promote on (e.g., OIPC, OFAH) social media releases (e.g., tweets, posts) and City of Mississauga social media platforms • Encourage the use of EDDMapS; a free application ("app") for recording invasive species which would, in turn, benefit the City's knowledge-base of invasive species in the City

Priority invasive species suitable for public participation include:

- Garlic Mustard,
- Goutweed,
- Buckthorn,
- Non-native Honeysuckle,
- Non-native Euonymus,
- Periwinkle,
- Common Reed, and
- Himalayan Balsam

Additional priority invasive species may be determined to be suitable for public involvement depending on the mechanisms of control recognized under evolving best management practices.

5.0 Concept Communications Plan

5.1 General Communications Strategy

Communication is a key component of an effective invasive species management plan, which in turn is vital to ensuring effective and successful implementation. The objective of the Communication Plan is to promote the success of the project by meeting the information needs of stakeholders. Engaging the City's partners, including neighbouring municipalities, local Conservation Authorities, non-profit organizations and the public, requires a Communications Plan that:

- Defines key stakeholders/partners for a given area,
- Defines clear, measurable communication objectives,
- Includes key messages and information for dissemination, and
- Provides a mechanism to measure and monitor the communication activities.

Monitoring communication activities will ensure that the Communications Plan can adapt to changes in key issues (e.g., target species and areas) and stakeholders/partners over time. The following sequential steps are recommended for the development of a communications plan (Inett and Shewchuk, 2003):

1. Review existing information
2. Develop clear goals and objectives
3. Identify target audience
4. Develop key messages
5. Prepare communications strategy
6. Evaluate outcomes

These steps are discussed in detail in Sections 5.1.1 to 5.1.6, below (adapted from Innet and Shewchuk, 2003).

5.1.1 Review Existing Information

The first step is to review existing information from City staff or other groups, such as existing communication strategies or plans. The review should consider the following:

- Available resources,
- Experience with similar communication activities within the City and by partners (e.g., CVC),
- Major communications opportunities (e.g., annual meetings, neighbourhood associated events, social media), and
- Communications impediments (e.g., budget, schedule, staff resources).

5.1.2 Goals and Objectives

Goals

Generally, there are two types of goals: an overarching communication goal and a specific communication goals. The overarching goal will state what is intended to be achieved through the project, such as:

To partner with the community to manage invasive species within Mississauga's Natural Areas.

The specific communication goal states what is planned to be achieved through the communication to further meet the

overarching goal, such as:

To engage and encourage residents, schools, businesses, and local community groups to implement invasive species management on public land and private property using existing programming and partner relationships.

These goals provide the framework for the development of the communications plan.

Objectives

The objectives should form a clear statement of what it is trying to be achieved. They should be specific, measurable, realistic, and listed in order of importance.

Based on the goals outlined in Section 5.1.2, examples of objectives (listed in order of importance) could be to:

- Achieve support for activities from local civic leaders
- Inform the community of the benefits of invasive species management
- Encourage positive media coverage of management activities and events
- Increase active stewardship by volunteer-base by 10%
- Ensure all stakeholders are identified to reduce health and safety concerns when pesticide use is planned.

5.1.3 Identify Target Audience

The message should be tailored to the target audience. Target audiences can be internal (within the City's departments) or external (community, other stakeholders). A list of such audiences could include:

Internal Target Audiences

- Mayor and Members of Council
- Environmental Action Committee
- City Departments (Parks, Forestry & Environment, Transportation & Works, Planning & Building, Recreation)
- City Employees – ambassadors

External Target Audiences

- Residents
- Schools
- Businesses - general
- Businesses - directly relating to invasive species (e.g., plant nurseries, landscaping companies)
- Ratepayer's Associations, Mississauga's Residents' Associations Network
- Stakeholders (e.g., CVC, Region of Peel, MNRF, TRCA, Ecosource)
- Communications representatives (e.g., news and media)
- Community groups (e.g., garden clubs and 'friends of' clubs)

Once the target audiences have been identified, the following should be considered to better inform the communication strategy:

- What do they already know about the City's invasive species management activities?
- How are they likely to react to the message and why?
- What are some factors influencing the audience that receives the message (e.g., literacy levels, ESL, or multicultural differences)?
- Are there any difficulties that might occur while communicating with each group?

5.1.4 Develop Key Messages

Considering the objectives and target audiences, the key message or messages to be communicated can be identified. Developing key messages will ensure consistency across all communications and will enable all persons asked to speak on behalf of the project to be informed. Developing the key message(s) should consider the following:

- Level of existing knowledge from audience about this issue
- Additional information the audience should be provided with

The information and key messages provided to the audience should be related to their needs/interests in order to attract interest and increase motivation by audience members to get involved. Clearly describing the benefits to the intended audiences will help ensure that the message is received, understood, and acted upon. The message(s) should be simple, specific statements, such as:

- Invasive species can negatively impact native wildlife in the City's natural areas
- Invasive species can be successfully managed with active participation from the community
- The community can work together to improve the health and aesthetics of the natural area through invasive species management

5.1.5 Communications Strategy

There are many ways to communicate a message. Based on previous steps, the choice for communication avenue can be narrowed to those that:

- Fit with the current resources (e.g., Twitter, Facebook, website, newsletters)
- Are the most effective way to communicate to reach the target audience and encourage engagement
- Help to achieve the goals and deliver the desired outcomes
- Work with the timing of other events (i.e., does not compete with other activities or events such as tree planting)

Table 8 provides a detailed list of avenues of communications that can be used to disseminate project information, engage stakeholders, stimulate discussion, and retain volunteers. Key products that should be developed to further the Communication Strategy and unify the project message include:

- Page on City's website: should include key messages, key links to supporting and relevant documents, partners, and contact information.
- Background documentation: ISMP background document, link to NAS reports.

To implement the communications plan, prepare a list of all the activities that should take place:

- Before (e.g., preparing a mailing list, writing a news release),
- During (e.g., distribution of the news release), and
- After (e.g., responding to community and media inquiries resulting from the news release).

If a long-term communications plan is developed, it is important to regularly monitor progress and make adjustments to the communications plan.

5.1.6 Evaluation

To determine if the communication was successful, the communications plan can be reviewed to determine how well the plan worked with target audiences, which activities had the most

Table 8. Avenues of communication.

Communication Avenue	Examples
Paid Advertising	• print – newspapers (e.g., The Mississauga News) or magazines (e.g., SNAP Mississauga, Mississauga Life, UoT Mississauga Magazine)
Print Materials	• brochures/pamphlets/publications – use existing information for species specific information (e.g., fact sheets from Invasive Species Centre, Ontario Invasive Species Centre and the Ministry of Natural Resources and Forestry) • newsletters – provide articles to community groups and other organizations for inclusion in their newsletters
Media Relations (indirect)	• website postings (e.g., mississauga.ca, mississauga.com, City's internal website) • feature articles (e.g., SNAP Mississauga, Mississauga Life, UoT Mississauga Magazine) • one-on-one interviews with the media (e.g., newspaper, radio (e.g., CBC, AM 640), television (Breakfast Television))
Public Service Announcements (PSAs)	• cable television and radio often accept community PSAs (e.g., The Haze, Boom, Virgin)
Community Relations	• direct mail - direct, expensive • public speaking (e.g., workshops, library presentations) - very effective personal contact, needs time commitment • video – YouTube (e.g., Bruce Trail Conservancy) • site tours open to the public (e.g., demonstration sites) - provide in-depth information, can eliminate suspicions • educational opportunities - visit classrooms, meet with local schools/teachers
Organization/Corporate Communications	• special events (e.g., volunteer events such as Garlic Mustard pull, tree planting) • trade shows (e.g., The Green Living Show) • annual and other reports • 311 updates
Internal Communications	• meetings • email messages • employee special events (e.g., divisional events)

impact, and which parts of the plan did not achieve the desired outcome. Measurement techniques can be employed to evaluate the plan, including:

- Number of hits to webpage,
- Number of people requesting information,
- Number of volunteers attending events,
- Number of shares on social media monitoring,
- Surveys and/or general inquiries with staff or stakeholders to determine level of comprehension, awareness, and
- Focus group sessions.

Evaluation of the communications plan should result in changes to improve future communication and outreach.

5.2 Landowner Contact Program

Informing private landowners of the importance of invasive species management should follow a landowner contact program that provides tools to build a relationship based on respect, understanding and trust. Most landowners value the natural environment and want to do what is necessary to protect it. However, they do not always understand the best way to go about this, nor are they always aware of actions they undertake that negatively impact the environment by introducing invasive species or allowing their spread (e.g., dumping yard waste from their backyard into a natural area, planting invasive plants as ground cover such as Goutweed). Informing landowners of the potential threat of invasive species to human health, the impact on ecosystems, the use of certain gardening practices, and what landowners can do to manage invasive species in their own backyards can empower them to be better stewards of our natural environment. Furthermore, engaging landowners in the management and stewardship of their natural areas can help

achieve the goals of the ISMP&IS and increase the community's sense of place and belonging in the City.

Primary objectives of the landowner contact program:

1. EDUCATE about invasive species (e.g., what are invasive species, don't dump yard waste, don't plant invasive plants in your garden adjacent to natural area)
2. INFORM landowners why, when, and what management activities will be occurring
3. INVOLVE landowners in reporting, monitoring, and volunteer opportunities

Prior to contacting landowners, the following should be considered to help guide landowner contact program:

- The number of landowners that can be realistically contacted without being over-whelmed
- Available time and resources to contact landowners
- Constraints and limitations (e.g., privacy laws) to contacting landowners
- Realistic expectations of landowners and landowner expectations of the City
- City staff contact person

Based on these considerations the message(s) that you wish to impart must also be determined prior to landowner contact. The message(s) will vary depending on the objective of the landowner contact (e.g., educate, inform, and/or involve). The following list will help guide the development of the message:

- Introduce who you are,
- Why you are contacting landowners,
- Purpose and goals of landowner contact,
- Describe benefits to landowner by becoming engaged/involved, and
- Provide City staff contact information to encourage continued communication and to build trust.

The message should be clear, consistent, and simple, avoiding technical and complex scientific terminology (Duynstee, 1997).

To determine where landowner contact programs should focus, priority geographic areas for landowner contact should first be identified. Landowners in the following areas would be a priority for contact:

- Priority areas for management (i.e. high quality natural areas identified in the Background Report),
- Areas where spread of invasive species from rear yards is prevalent,
- Communities where management is about to occur in adjacent natural areas, and
- Areas where there is an existing active neighbourhood/community group (in order to leverage volunteer opportunities).

5.2.1 Targeted Outreach Program

Identify landowners adjacent to natural areas and other priority geographic areas using mapping software, landowner information in the City's database, and information collected during the City's other management activities (e.g., Ash tree removal). Note: it is important to follow applicable privacy laws/policy (e.g., Municipal Freedom of Information and Protection of Privacy Act, R.S.O. 1990, The City of Mississauga's Web Privacy Statement) when using private information and contacting the public (e.g., mass e-mails should comply with Canada's Anti-Spam Legislation, 2014).

Key targeted outreach programs are provided in Table 9.

Table 9. Key targeted outreach programs.

Program	What	Where	How
Flyer drop-off or targeted mail-outs	Passive program including general information about invasive species	To be used in neighbourhoods adjacent to natural areas where management is occurring.	Door-to-door: important to do when management works are about to occur directly adjacent to landowners to inform adjacent landowners activities can be expected (e.g., why, when, and how), or in areas where there are real issues with invasive species originating from rear yards. Complete door-to-door landowner contact during the day if you can, however if limited success is achieved during the day (few people are home), it may be necessary to complete some door-to-door contacting in the evening.
Workshops targeted to community local to natural area	Educate public about invasive species impacts to natural areas, what they can do to reduce introductions and spread of invasive species and how they can get actively involved in invasive species management through volunteer opportunities.	Advertise to neighbours of community surrounding natural area where management activities are to occur.	Invite members of the public to sign-up for volunteer/community invasive species management events with notices through social media, City's website, stakeholder/partner newsletters or asking them to distribute information via their e-mail lists.
Media	Advertise about local events and inform about invasive species	Social media including Instagram, Facebook, Twitter, and YouTube.	Follow communications strategy to reach out through various media avenues. Use the City's website to post a volunteer activity calendar where residents can sign up for notifications about events in the City.

5.2.2 Resources for Landowners

There are various sources of existing information that can be provided to landowners in order to educate, inform and involve them in invasive species management. For each of the targeted outreach programs, pamphlet types or information guides should be provided, such as:

- Species specific information (available from the Invasive Species Centre, Ontario Invasive Species Centre and the Ministry of Natural Resources and Forestry)
- Involvement information which describes how residents can get involved including types of projects, contact information, and direction to volunteer activity calendar on City website (with automatic notification of upcoming and/or posted events), or a simple one page leaflet to hand out at public events

5.2.3 Tracking Communication

It is recommended that whichever form of contact is used, a database be kept to document communications. This database will help inform future landowner contact efforts to ensure that an area/individual is properly contacted and to track efforts. Fields suggested for the contact database can include:

- First name
- Last name
- Preferred phone
- E-mail address
- Street
- City
- Province

- Postal code
- Activity record number/code
- Interest in involvement
- Interest in additional information and future contact
- Do not contact in future

5.3 Stakeholder Notification Program

For the purposes of this plan, stakeholders are individuals or groups that may have interest in the work being conducted through the ISMP&IS. Stakeholders should be notified in two occasions with respect to invasive plant control: when pesticides will be used to complete work, and when significant changes to the landscape will occur.

Invasive species control may require the use of pesticides by contractors. In situations where pesticides are being used, it is necessary to provide notification of any work with health and safety risks to surrounding land owners in advance of the work beginning. It is also suggested that stakeholders be contacted in advance of any significant landscape changes, including the removal of a substantial amount of woody invasive species that may significantly impact the scenery (e.g., change the privacy level of a resident's yard). Stakeholders suggested to receive notification of work and associated timelines and communication method(s) are listed in Table 10.

Table 10. Stakeholder Notification.

Stakeholder	Timeline	Communication Method
Residents living directly adjacent to work locations	1 week prior to work commencing	Mail drop
Schools within 2 kilometres of work locations	1 week prior to work commencing	Mail drop or email
Businesses directly adjacent to work locations	1 week prior to work commencing	Mail drop or email
Community Partners (e.g., CVC, Region of Peel, MNRF, TRCA, Ecosource)	2 weeks prior to work commencing	Email
Community groups (e.g., garden clubs and 'friends of' clubs)	1 week prior to work commencing	Email
Mississauga Staff including Forestry Supervisors, Parks Supervisor, and Councillor's Office	1 week prior to work commencing	Email
Public Park Users	1 week prior to work commencing	Signs posted
311	1 week prior to work commencing	Email

6.0 Management of Invasive Flora

Invasive species management is composed of three general activities:

- Baseline Inventory
- Monitoring
- Eradication or Control

Invasive species-specific location data is generally unavailable for each of the priority natural areas. NAS data is collected on a site by site basis, as opposed to per vegetation community; therefore, there is no data available on the quality of each vegetation community in each natural area. Therefore, an initial baseline inventory of priority natural areas is required to identify the location and size of invasive populations. This information will help guide the management efforts of invasive species.

Baseline inventory and monitoring efforts in priority natural areas before and after implementation of management measures will inform decisions to start, continue, or stop control efforts. Monitoring is also necessary to make informed decisions on what restoration measures to use. Monitoring after control efforts will inform decisions of when to begin control measures again, or confirm that control/eradication measures have been successful.

6.1 Baseline Inventory and Monitoring

The first step for invasive species management at each of the demonstration sites (see Section 12) is identifying populations suitable for management. Following the identification of populations suitable for management, a decision making tool can be used to determine when it is appropriate to implement control strategies. The sections that follow (up to and including Section 6.4.1) detail this process and provide guidance for those executing the invasive species management strategies under the ISMP.

There are two types of surveys required to inform invasive species management of flora:

1. Baseline inventory
2. Monitoring

The purpose of the baseline inventory is to document species and populations (size and extent) of top priority invasive species. The purpose of monitoring is to detect changes in the presence of invasive plants and/or trends such as an increase or decrease in population size. Overall, the purpose of this exercise is to enable the City to detect populations early, and respond quickly to invasive species that require immediate attention, and to effectively manage invasive species that are currently established.

Goal and Approach

The goals of the baseline inventory and monitoring are to gather information required to:

1. prioritize management:
   a. between natural areas, and
   b. within natural areas (prioritizing populations)
2. determine control approach and management initiatives (e.g., restoration planting).

It is necessary to apply a consistent approach to reliably determine

trends and ensure consistency in data collection. This will allow trends to be analyzed that reflect real changes in the population being monitored. The approach to monitoring, especially the attributes selected for measurement, must satisfy this requirement. It is inevitable that monitoring will be undertaken by different people from time to time, thus the methods must be unambiguous and require little or no interpretation (Geomatics International Inc., 1995).

To develop an inventory and monitoring framework, the following approach should be followed:

1. Decide on appropriate intensity of inventory and monitoring by:
    a. selecting where monitoring will be completed,
    b. establishing boundaries for monitoring,
    c. determining mapping requirements,
    d. determining best time(s) of year for monitoring, and
    e. determining frequency of monitoring.
2. Document a detailed procedure for data collection (technique) to ensure consistency over time and staff changes

6.1.1 Inventory and Monitoring Techniques

Inventory Considerations

The inventory type will depend on the most efficient use of resources (staff and money) while obtaining the most useful information to guide management. There are a number of methods to inventory and monitor invasive species populations (e.g., plots, transects), however, by targeting areas where invasive species initially become established (e.g., trails, edges, adjacent lands), monitoring can be completed efficiently and effectively. Monitoring will be completed on City-owned lands, as these are the lands where the City has ability to implement invasive species control measures. As such, the boundaries for monitoring is to be the City property boundaries within each natural area, with all monitoring activities occurring inside these boundaries.

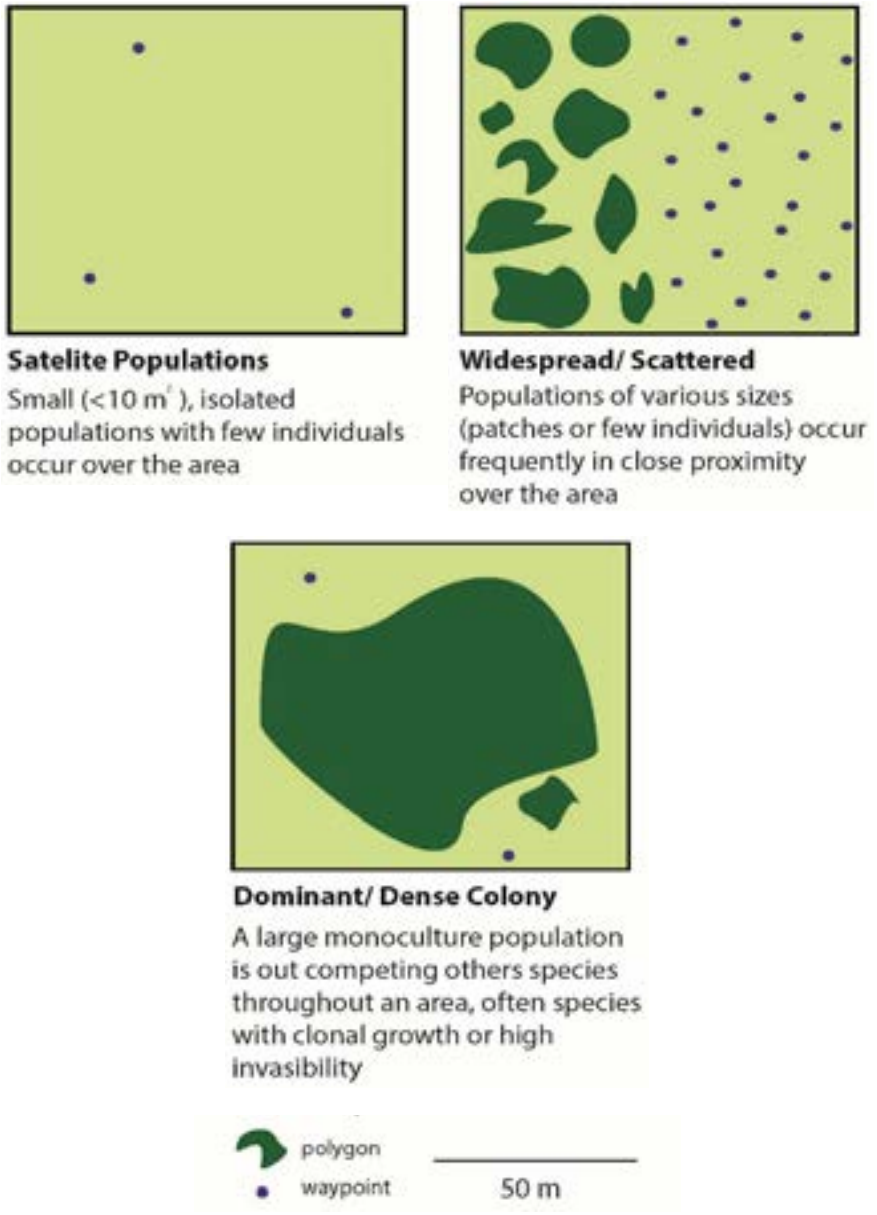
In most cases, the best time of year to monitor plants is during flowering, when they are most visible. Therefore, the time of year for monitoring will depend on individual flowering time of each of the priority invasive species. As the purpose of monitoring is to detect changes over time and respond rapidly to populations that are considered to be an issue, after the initial baseline inventories, monitoring should be conducted frequently enough to meet these conditions. The priority invasive flora identified for the City are generally prolific spreaders. As such, annual monitoring is recommended to enable the City to respond and adapt the management plan to changes in species populations, locations, and new arrivals.

Inventory Preparation and Mapping

Prior to field surveys, mapping and a field plan should be prepared. The field plan would identify the areas of focus for the field survey, and the mapping will aid in this process. Mapping of the natural area or area of interest can be printed in hard copy or remain in digital format, depending on the availability of resources. There are efficiencies in data collection if data (e.g., polygons, waypoints, and species information) can be digitally entered in the field into technology such as a tablet. Programs exist for tablets whereby polygons can be drawn digitally on the tablet, waypoints can be located, and species information associated with a polygon/waypoint can be entered. Alternately, a hard copy of the map can be printed and marked up in the field, with the associated field data sheet (Appendix 4). Mapping requirements and features to identify during the field planning process are listed below in a sequential process:

1. Identify natural area for inventory/monitoring

Figure 1. Illustration of various densities/distribution of populations of invasive plants mapped as a polygon or waypoint.



2. Prepare a map (digital or hard-copy) that includes the following information:
    a. Current aerial photography
    b. Natural area boundary
    c. City property boundary
    d. Available trail information (formal trails, and where information exists, informal trails)
    e. Watercourses
    f. ELC community codes and boundaries
    g. Locations of historical and current structures (e.g., buildings, homesteads, foundations) and closed roads/ laneways/driveways
3. Identify high quality ELC communities (Appendix 3) and rare vegetation communities (Section 3.4.2) to be surveyed
4. Identify historical/current structures to be surveyed
5. Identify access points

Inventory Field Survey

The field surveys will focus on areas where there is the greatest potential to find invasive flora (e.g., trails, around historical and current structures), areas of higher vegetation quality where it is more likely to identify small populations, and rare vegetation communities. As mentioned previously, it is easiest to identify/ locate invasive flora during the species flowering period. Suggestions for survey period are identified below, as well as a list of instructions as to where/how to survey for invasive species in each natural area.

Field survey protocol includes walking through/around/on:

1. formal and regularly-used informal trails (e.g., informal

trails that are at least 1 m wide and appear to be used frequently); those trails near watercourses will be used to view the edges of permanent and ephemeral water features,

2. City property boundary,
3. "communities of interest" (e.g., ELC communities identified as high quality in Appendix 3 and rare vegetation communities (Section 3.4.2)). Be purposeful with the path taken through these communities in order to walk through areas that likely contain invasive species and digitally track the path (with handheld GPS unit) taken during the initial inventory survey so that the same path can be followed in subsequent monitoring surveys), and
4. around old homesteads and other anthropogenic structures built within natural areas.

Two annual survey periods are recommended to document species in peak flowering time. Surveys should be completed in the spring and summer. The first survey will be limited to wetland habitats in May and will focus on one priority invasive spring ephemeral species: Fig Buttercup (Ficaria verna) and Giant Hogweed. Although Giant Hogweed is not flowing in May, this species is recommended for survey to allow for herbicide treatment earlier in the year when the plant is smaller and prior to seed production. The second annual survey is recommended to be in late-summer (i.e. June/July) for the remaining priority invasive species.

Data Collection

As discussed above, data can be collected digitally using a tablet, or in hard copy using maps and field data sheets. The following data collection methods should be followed to produce consistent results.

- Mark polygons and waypoints of invasive species populations (see Figure 1 for example of waypoints vs. polygons)
- Polygons can be marked for individual species as well as mixed species populations
- Waypoints can be marked for small populations (e.g., <10 m^2 in area)
- Distance from trail that polygons are identified will depend on location and visibility (e.g., can see further into an open woodland as compared to a thicket). Therefore, distance from the trail will vary, however, surveyor should generally stay on the trail while conducting surveys in order to produce consistent results (only straying slightly off of path to be able to accurately determine the extent of a polygon that starts at the edge of the trail)
- Polygons can be marked on a hard-copy air photo with associated notes and waypoints documented on a datasheet, or information can be entered digitally on a tablet with orthoimagery and GPS capabilities.

Common Reed is considered to be invasive because of its ability to reproduce clonally and quickly invade wetland areas. Photo by CVC.

Within-site species distribution can be:

- scattered/widespread: many plants scattered evenly throughout area,

- patchy: larger (>10 m^2) plant populations in distinct patches,
- a combination of scattered and patchy: a dense patch that becomes more scattered further from the dense patch, or
- contain very few individuals: e.g., satellite population with few individuals in small group (<10 m2) (Geomatics 1995).

Scattered/widespread distributions and large patches both lend themselves to being identified by polygon, whereas small patches (i.e. satellite populations) and individual plants lend themselves to being identified by waypoint. Spatial distributions are illustrated in Figure 1.

Templates for field datasheets have been created in order to support the efficient and directed collection of data from the monitoring activities. These forms are available in Appendix 4. Datasheets should be considered living documents and shall be updated over time to accommodate field-fit, new information, and/or new coordinated strategies.

6.1.2 Mapping of Invasive Species

Existing information as well as information collected through a monitoring program can be entered into a GIS database that can map populations and identify areas of high concentrations. A key component in an invasive species program is early detection and rapid response (EDRR), which is the "early detection of, and rapid response to, invasive plants and insects to increase the possibility of controlling and potentially eradicating these species before they become established, or spread further across the landscape" (Early Detection and Rapid Response Network Ontario, 2015). Species distribution mapping information will show the size, direction of spread, rate of spread, and other relevant information that pertains to management and control strategies for the target species. Mapping can be used as a tool to identify high priority areas and provide early detection of newly reported invasive species.

Attributes associated with mapping should include:

- Species identification,
- Population size,
- Population density, and
- Growth stage.

Additional documentation of invasive species, such as the Early Detection and Distribution Mapping System (EDDMapS) for Ontario, can be incorporated into the City's database of invasive species occurrences in the City. EDDMapS is a web-based mapping system for documenting invasive species distribution by mapping and tracking infestations of invasive species in real-time. It combines science with technology, works across agency, organization, and discipline boundaries, and is contributing to the visualization of the distribution of invasive species across the United States and Canada. Through this platform the City will be able to access geo-referenced Citizen Science records of invasive species. There is also an opportunity for information sharing through bulk data submissions from the City to EDDMapS. The City should consider sharing data on invasive species collected under the guidance of the ISMP&IS in order to contribute to the regional, provincial, national, and international harmonized efforts to understand, map, and forecast the movement and characteristics of invasive species.

6.2 Management Triggers - Flora

Management triggers help to guide action measures and ensure resources are being optimized by directing resources effectively. Management triggers for priority invasive flora must consider a number of factors in order to be comprehensive and effective. Considerations for managing invasive plants include:

- Spatial distribution and population size
- Traits of invasive plants

- High quality and rare vegetation communities
- Level of disturbance
- Effect on SAR flora and fauna.

Spatial Distribution and Population Size
When considering the extent of invasive flora populations, the most cost effective and best chance for reducing/eliminating a population is to target small/isolated populations (i.e. satellite populations) (Veitch and Clout 2002). Generally, established plant populations have a well-developed seed bank and/or extensive rhizomes making their removal more difficult and costly than satellite populations.

Traits of Invasive Plants
Species vary in their rates of reproduction and spread, and therefore should be treated differently depending on these characteristics. Species that reproduce and spread rapidly will require more immediate attention than those that are not as aggressive. However, the impact of these species also depends on the quality of the area.

High Quality and Rare Vegetation Communities
High quality (Appendix 3) and rare vegetation communities (Section 3.4.2.) containing invasive flora are considered a high priority for control measures. High quality vegetation communities typically contain a high relative abundance (and often diversity) of native flora, with a higher degree of ecological function and resiliency. Generally, high quality areas have a greater potential to be more resistant to invasion. These areas typically contain a relatively low abundance of invasive species that are often found in smaller, isolated populations (i.e. satellite populations), as opposed to dense, widespread colonies that are more established.

Level of Disturbance
Disturbances due to tree removal, construction activity, etc., alter the environmental conditions in the area including sun exposure, soil characteristics (e.g., soil moisture, compaction) and local climatic conditions (e.g., increased exposure to wind, warmer temperatures). Disturbances favour the introduction of invasive species that are generally highly adaptable. These areas may require attention to avoid becoming a source for invasive plant spread.

Effect on SAR Flora and Fauna
Natural areas may also contain SAR flora that could be threatened by invasive flora. The locations of known populations of SAR are documented through the NAS. Since invasive species have the ability to alter the ecosystem within which they occupy, there is a potential they may impact the environment in which SAR inhabit and rely on for survival. SAR are protected under the Ontario's Endangered Species Act, 2007, S.O. 2007 c.6, as such, consultation with the Ministry of Environment, Conservation and Parks (MECP) should take place prior to commencing with management efforts within the regulated habitat of threatened and endangered species. Since invasive species management can benefit SAR and their habitat, the presence of SAR is considered a trigger for control measures.

6.2.1 Active Management Decision Tool
Taking into account the above considerations for invasive flora management triggers, a decision matrix was created to help guide management decisions. Figure 2 illustrates a decision matrix which begins with baseline inventories (as discussed in Sections 6 and 7), and works through decisions of when to start control measures, continue monitoring, and when to stop or continue control measures. Management triggers are identified by numbered circles and are defined in Table 11. Table 11 identifies the triggers associated with each management decision. Monitoring is always recommended with each management decision (as described in Sections 6 and 7).

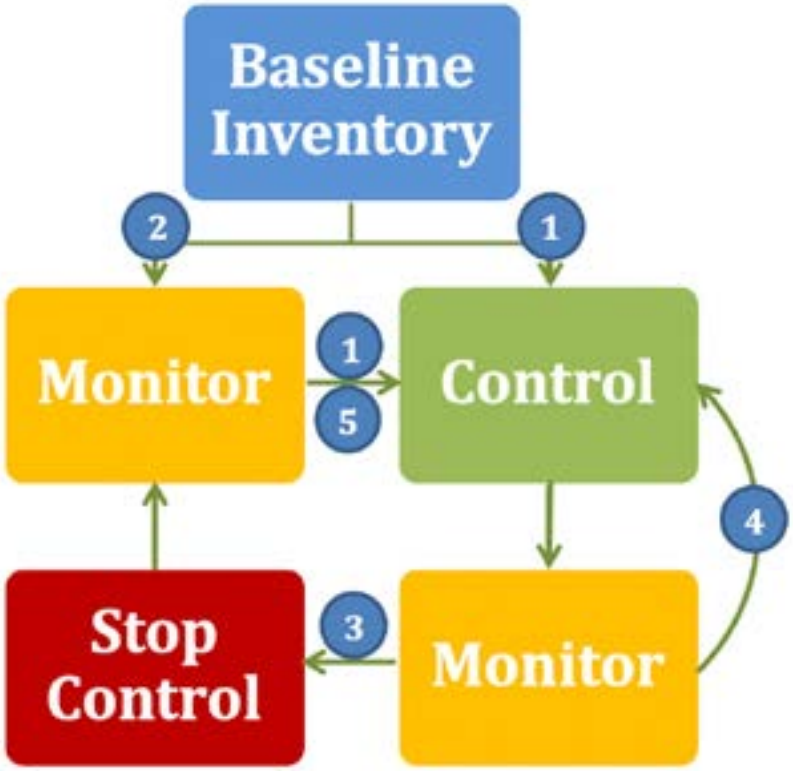
Table 11. Triggers to determine when to start and stop invasive plant control measures in high priority natural areas.

Trigger #	Management Triggers	Definitions and Examples	Action
1 **(Prior to any control measures)**	Species reproduce and spread most rapidly	• Manitoba Maple (young) • Goutweed • Garlic Mustard • European Alder • Oriental Bittersweet • Autumn Olive • Russian Olive • Fig Buttercup • Non-native Honeysuckles • White Mulberry • Buckthorn • Dog-strangling Vine • Tree of heaven • Non-native Euonymus species • Japanese Knotweed	**Start control measures**
	Noxious weeds	• Giant Hogweed • Wild Parsnip	
	Presence of invasive species competitors in vicinity of Butternut	• Competitors are considered to be any invasive species that could shade or suppress the growth or regeneration of Butternut • Vicinity is considered to be any area where an invasive species would shade Butternut or outcompete for resources	
	Area Characteristics		
	High quality and rare vegetation community	See Appendix 3	
	Recently disturbed area	Examples: • EAB tree removals • Disturbed forest edge • New development • Heavy trail use (e.g., unauthorized bike skills courses) • Soil compaction • Vegetation trampling	
	Population Characteristics		
	Small isolated/satellite population	• Isolated populations are those that occur far away from other invasive populations • Satellite populations are those that occur separately from a large dense population	
	Newly-established population	• Not detected in previous monitoring	
	Rapidly expanding populations	• Detected through monitoring over time—greater than or equal to 50% area increase in 1 year	
2	Trigger # 1 not present	• Low quality area • Stable populations (i.e. not expanding) • Large established population • Surrounding native flora unaffected (e.g., not shaded) by invasive population (provide list of species - no immediate control)	**Monitor**

Trigger #	Management Triggers	Definitions and Examples	Action
3	**Characteristics of Trigger #1**		**Stop control measures**
	Stable populations	• Area covered by invasive species is not expanding	
	Population decrease	• Decreasing below a management threshold	
	Eradication of noxious weeds	• Noxious weeds are no longer present	
	Eradication of small satellite/isolated population	• Small/isolated populations have been removed with no regeneration noted during monitoring	
4	**Characteristics of Trigger #1**		**Continue control measures**
	Invasive flora continually spreading	• Observed expansion/increase in area of invasive species	
	Invasive flora continually sprouting in managed areas	• Management not successful	
	Invasive flora present and able to spread continually	• e.g., DSV is continuous compared to Buckthorn which takes 5 years to germinate	
5 (After previous control)	Newly established species listed in Trigger #1 are now present	• Trigger #1 species that were not present in the past are now present	**Start control measures**
	Previously controlled species populations are now spreading	• A population that was either stable or decreased is now expanding	
	Small satellite/isolated populations of previously controlled species are now occurring	• Populations of previously controlled species occurring where they did not occur previously	
	Species newly established in high quality, rare vegetation community or recently disturbed areas (as in Trigger #1)	• e.g., any priority species newly established in a high quality or rare ELC community as listed in Trigger #1 • e.g., any priority species newly established in a recently disturbed area	

Triggers apply to both established populations and initial/recurring/newly-occurring populations of priority species. Only one trigger is required to undertake the recommended action. Trigger numbers relate to Figure 2.

Figure 2. Decision matrix for invasive species management. Management triggers are identified by numbered circles that are defined in Table 11.



6.3 Control Methods - Flora

Active management of invasive plants must continue for at least five years post initial management activity. Some seeds are viable in the soil for five years (e.g., Garlic Mustard, Wild Parsnip and Buckthorn), and the soil may contain an abundance of seeds where a population is well established (Anderson, 2012a; Anderson, 2012b; Tassie and Sherman, 2014). In the absence of continued control, there is the risk that invasive species re-sprout from cut stems or remaining roots in the soil, or that seeds will germinate in the recently disturbed soil, potentially resulting in a more dense population of invasive plants.

The control of invasive plants requires the accurate identification of species and knowledge of the surrounding ecosystem. These are essential to making informed decisions. The method of active management employed to control or eradicate an invasive plant population varies based on factors including: resources (e.g., people and money), effectiveness (i.e., if the method can remove that species successfully), public acceptance, time of year, as well as plant species, extent, and guild. There are four control methods typically used to remove/eradicate invasive plants:

- Mechanical
- Chemical
- Controlled burns
- Biological

Mechanical and biological control methods have a number of techniques which can be employed to achieve invasive plant control. These control methods and techniques are described in Table 12. It is important to note the time of year when implementing these control measures. Time of year has an impact on the stage of the vegetation; whether it has produced vegetation and is readily identifiable and manageable, what the current stage of seed/fruit production is and whether it

can be managed without the potential for further spread, and considerations such as seasonal land uses by residents of the City. These factors inform the timing of control, or the type of control measure that is best suited for that particular time of year. For example, it is best to pull Garlic Mustard prior to seed production; however, it is also recommended that the pulling not be done too early in the year in order to allow for there to be sufficient vegetative structure to pull (otherwise regrowth will occur). In contrast, if it is later in the year and Garlic Mustard has gone to seed, a chemical treatment would be more effective than pulling the plants which would only result in spreading the seed. It is recommended that whenever possible, these control measures increase the effectiveness of the control measure.

An integrated, ecosystem-based approach using combination of the above listed control methods often results in the greatest control of invasive plants.

6.3.1 Noxious Invasive Plant Management

Giant Hogweed and Wild Parsnip contain phototoxic chemicals in their sap called furanocoumarins that can cause severe burn-like rashes (MacDonald and Anderson, 2012; Tassie and Sherman, 2014). Giant Hogweed is more toxic than Wild Parsnip but both should be managed carefully (Durham Region, 2015). These species were purposely excluded from Table 12, Summary of Invasive Flora Control Methods and Techniques, in order to provide specific direction for management of these species. Due to the health risks involved with removal and disposal, Giant Hogweed and Wild Parsnip are not appropriate for community engagement activities.

Mechanical Control Methods

Giant Hogweed reproduces by seeds after 2-5 years of growth. Mechanical control methods for Giant Hogweed should be completed in early spring before the plants go to seed. Due to the large size of Giant Hogweed, mowing and tilling are impractical and may pose a risk of exposure to toxins in sap. Digging may be used to remove Giant Hogweed in the first year of growth but is challenging as the root system can be over 1 m long and the entire root must be removed to effectively remove the plant (MacDonald and Anderson, 2012).

Wild Parsnip only reproduces by seed, therefore preventing seed production can reduce population expansion. This species can be removed by methods including mowing, pulling, tarping and herbicide application (Tassie and Sherman, 2014). Tilling larger areas may provide a chance for other species to out-complete Wild Parsnip but is not effective at removing the species entirely from an area. Tilling and mowing methods may also pose risk to exposure of toxins through sap and should be completed cautiously with appropriate PPE (Tassie and Sherman, 2014).

Weed wrenching is a method of invasive plant control used for species such as Buckthorn. Photo by CVC.

Chemical Control

Herbicide treatments are the most effective way to manage noxious plants and reduce risk of coming into contact with toxic sap. Glyphosate herbicides are recommended by the Giant Hogweed Best Management Practices (MacDonald and Anderson, 2012) although labels should be checked to determine if the product can be used for Giant Hogweed. Since herbicides only kill green vegetation, areas should be covered in mulch 10-14 days after application to prevent growth of seedlings.

Table 12. Summary of invasive flora control methods and techniques for priority invasive flora (excluding Giant Hogweed and Wild Parsnip).

Control Method	Technique	Description	Suitable Vegetation	Suitable Priority Species	Tools/Materials Required	Advantages	Disadvantages
Mechanical	Hand Pulling or Digging	• hand pulling invasive plants • weed-wrenches can also be used for woody species • can be used as an interim measure while other methods are being planned or waiting for permissions • must dispose of plant material that is removed	• most effective for species without rhizomatous root systems	• Autumn Olive • Buckthorn • European Alder • English Ivy • Fig Buttercup • Garlic Mustard • Goutweed • Guelder Rose • Himalayan Balsam • Manitoba Maple • Non-native Honeysuckles • Norway Maple • Oriental Bittersweet • Periwinkle spp. • Russian Olive • White Mulberry • Non-native Euonymus spp.	• weed-wrenches • Extractigator® • shovel	• low-overhead cost • low danger • sometimes effective • can often be done by volunteers with minimal training	• can be difficult to remove all roots • labour-intensive • desirable native species can be trampled or pulled by mistake • will cause localized soil compaction • sometimes not effective
	Mowing and Cutting	• cutting of invasive shrubs and trees, often in conjunction with herbicide application • mowing of extensive area entirely dominated by invasive species (herbaceous or grass)	• all plant types	• Autumn Olive • Buckthorn • Common Reed • Dog-strangling Vine • European Alder • Garlic Mustard • Goutweed • Guelder Rose • Japanese Knotweed • Non-native Honeysuckles • Norway Maple • Oriental Bittersweet • Russian Olive • White Mulberry	• handsaws • power saws • brush-cutters • mower • weed-whipper	• some activities possible for volunteers (e.g., cutting) • simple, easy	• stressed woody plants are occasionally killed by cutting, but most survive and re-sprout • soil compaction with heavier machinery • larger equipment may damage adjacent native vegetation • cutting of deciduous woody invasive usually requires follow-up treatment with herbicide • species such as Japanese Knotweed will need follow up treatment (i.e. chemical) since this will not remove the population but makes it more manageable

Control Method	Technique	Description	Suitable Vegetation	Suitable Priority Species	Tools/Materials Required	Advantages	Disadvantages
Mechanical	Physical Covering - Mulching	• covers low-growing species • inhibits photosynthesis to slow or prevent further growth when mulch layer is at least 7.5 cm in depth • can be used in conjunction with a layer of newspaper or cardboard under the mulch to inhibit initial growth of invasive species • can be used for taller vegetation, after cutting/ mowing	• herbaceous plants and grasses that are either low growing or have been cut low to the ground	• Goutweed • Garlic mustard	• mulch • shovels • buckets • wheelbarrow	• adds organic matter to the soil as mulch decomposes	• less effective with time as mulch decomposes
	Physical Covering - Tarping	• used in areas of complete invasive species dominance • inhibits photosynthesis • reduces seedling regeneration • contributes to killing off the seedbank	• herbaceous plants and grasses that are either low growing, or have been cut low to the ground, or have been pulled or dug	• Common Reed • Dog-strangling Vine • Garlic mustard • Goutweed • Guelder Rose • Japanese Knotweed • Lily-of-the-valley • Periwinkle spp.	• tarps • landscape staples	• able to control large area of invasives with minimal cost or effort	• difficult to install on uneven ground, rocks, or stumps • often dug up by animals or vandals and some plants survive • results in large un-vegetated area that requires planting with native species to prevent re-growth of invasives • species such as Japanese Knotweed will need follow up treatment (i.e. chemical) since this will not remove the population but makes it more manageable
	Girdling	• a ring of bark is cut around the base of the stem severing the cambium and often the xylem preventing the flow of nutrients to the roots and water to the upper stem. The plant dies slowly as stored reserves in the roots are depleted. The cut must be done completely around the stem to be effective.	• used for large woody species that will not become a hazard (i.e. away from trails, adjacent properties	• Autumn Olive • Norway Maple • Manitoba Maple • Russian Olive • White Mulberry	• hand saw • hatchet • hand girdling tool (e.g., Ringer)	• less costly than cutting down entire tree • provides habitat for wildlife (e.g., birds feeding on insects) • if performed correctly, does not cause re-sprouting	• shrubs and young trees often re-sprout vigorously unless herbicide is also used in the cut • may continue to live or re-sprout if done incorrectly

Control Method	Technique	Description	Suitable Vegetation	Suitable Priority Species	Tools/Materials Required	Advantages	Disadvantages
Chemical	Spray or spot application	• often performed in conjunction with mechanical treatment • pesticides classified by effect, but most are systemic • can be applied to cut stumps, cuts through the bark (hack-and-squirt), or to outside of bark on young stems (basal bark treatment), or to foliage by wicks or sprayers • herbicides that top-kill only (i.e. vinegar formulations) are not usually effective except for annual species prior to seed set	• terrestrial invasive species with extensive root systems	• Autumn Olive • Buckthorn • Black Locust • Common Reed • Dog-strangling Vine • English Ivy • European Alder • Fig Buttercup • Garlic Mustard • Goutweed • Guelder Rose • Himalayan Balsam • Japanese Knotweed • Lily-of-the-valley • Manitoba Maple • Non-native Honeysuckles • Norway Maple • Oriental Bittersweet • Periwinkle spp. • Russian Olive • Tree-of-Heaven • White Mulberry • Non-native Euonymus spp.	• Pesticide Applicator's License • Integrated Pest Management certificate • chemical • application equipment • personal protective equipment (gloves, tyvek ® suit, rubber boots, etc.)	• effective tool for new and small populations of invasive plants • will kill target plants • can have residual control of seed-bank • less labour	• specialized training, certifications required • public concern for environmental health • potential for negative effects on non-target plants • restrict/avoid herbicide use near water bodies including wetlands (refer to the Ontario Pesticides Act 2009, for guidance and regulations) • Glyphosate needs to be applied immediately after cutting vs. Triclopyr which can be applied later in the growing season (note: Triclopyr is more expensive than Glyphosate)
Biological Control	Insects	• controlled release of invasive plant species predator	• vegetation that cannot be effectively controlled by other means • under development for Dog-strangling Vine	• experiments/ studies ongoing to determine effective and safe use	• suitable insects	• usually highly specific • often effective • can be self-sustaining (low-effort after initial introduction)	• possibility that biological control agent adopts other (e.g., native) plant hosts • will not eliminate a species but will reduce numbers to low levels • must be approved by federal and provincial authorities before release

Control Method	Technique	Description	Suitable Vegetation	Suitable Priority Species	Tools/Materials Required	Advantages	Disadvantages
Biological Control	Fungi and other Plant Diseases	• controlled release of co-evolved pathogens	• species with known pathogens in native range • species that cannot be controlled by mechanical/ chemical methods due to resistance and/ or environmental factors	• experiments/ studies ongoing to determine effective and safe use	• suitable pathogens	• usually highly specific and effective • can be self-sustaining (low-effort after initial introduction)	• possibility that biological control agent adopts other (e.g., native) plant hosts • highly-regulated federally, with extensive time and research • will not eliminate a species but may reduce numbers to low levels
Controlled Burns	Controlled fire in a specific area	• can reduce above-ground biomass that has been suppressing native vegetation • can kill most woody plants if done repeatedly, allowing dominance of herbaceous and graminoid (e.g., grasses) species	• species not adapted to a fire-controlled ecosystem	• Buckthorn • Non-native Honeysuckles • Oriental Bittersweet	• qualified control burn experts (contact Fire Management Program with MNRF for more information) • associated burn equipment	• part of integrated management plan for certain species or communities (i.e. tallgrass prairie or savannah)	• requires highly specialized knowledge and entails higher risks • not appropriate in some urban areas or conifer plantations due to risk of fire spread • does not kill plant roots; plants usually grow back but may be weakened and more easily controlled by other methods • high financial cost • need permission from fire department • narrow window of suitable weather conditions/season for it • will require more communication/ notices to surrounding community

The following sources were refernced to compile this summary table: (Good Oak Ecological Services LLC, 2016), (Invasive Species Centre, 2016, 2020), (Invasive Species: Species Profiles & Reporting Information: Plants, 2016), (Ministry of Natural Resources, Ontario Federation of Anglers and Hunters, Ontario Invasive Plant Countil, and Credit Valley Conservation, 2013), (Ministry of Natural Resources and Forestry, 2016), (Natural Resources Conservation Service, 2015, (National Park Service, 2016), (Tree Canada, 2016), (Winsconsin Department of Natural Resources, 2012).

Biomass Disposal

Noxious weed biomass should not be burned or composted (MacDonald and Anderson, 2012; Tassie and Sherman, 2014). This biomass should be allowed to dry out on site and placed in bags. Plastic bags should be disposed of through the local waste collection process.

Noxious Weed Health and Safety

The Giant Hogweed Best Management Practices (MacDonald and Anderson, 2012) and Wild Parsnip Best Management Practices for Ontario (Tassie and Sherman, 2014) state that anyone participating in removal or management activities must wear protective clothing including:

Giant Hogweed is a noxious invasive plant that should be removed with care. Photo by CVC.

- waterproof gloves,
- waterproof boots,
- eye protection (face shield), and
- long sleeve shirts and pants and/or disposable coveralls.

Disposable "spray suit" coveralls over normal clothing removes the risk of sap soaking through material and taping coveralls at the wrists minimizes potential exposure of skin to sap. Giant Hogweed and Wild Parsnip can cause severe burns within 48 hours of contact with the sap. If sap contacts skin wash the area with soap and water. If a rash develops seek medical attention. If sap enters the eye rinse with water and seek medical attention urgently

Table 13. Noxious invasive species control methods summary.

Giant Hogweed	Wild Parsnip
• Dig • Herbicide	• Dig • Herbicide • Pull • Mow • Tarp • Till

(MacDonald and Anderson, 2012; Tassie and Sherman, 2014). All equipment should be washed after use since the toxic sap may remain on these items.

6.3.2 Norway Maple Management

Norway Maple is listed as a priority invasive species for management due to its invasive properties in natural areas. Norway Maple has a dense canopy that can shade the understory restricting the growth and germination of native plants, and the dense root system of this species grows close to the surface outcompeting native plants for nutrients and water. However, Norway Maple is commonly planted in urban areas because these characteristics that make the species invasive in natural environments also make it a very successful street tree. As a street tree, Norway Maple are valued for their tolerance to stress, aesthetics, and rapid growth. With the loss of Ash trees as an option for planting in urban areas as a result of EAB, the value of Norway Maple in the urban canopy, particularly as a street tree, has increased.

Norway Maple is currently negatively impacting forested communities and should be managed within natural areas. However, considering the value of Norway Maple in the City, a strategy is proposed to reduce the impact of Norway Maples in natural areas while recognizing their value in the urban canopy.

In natural areas where management of Norway Maples is triggered based on the management decision matrix in Section 6.2, trees should be removed from natural areas in a systematic way that

does not drastically alter the tree canopy cover and microclimate conditions in the understory. In natural areas where Norway Maple is abundant, a multi-year approach to thinning them from the canopy should be followed. For example, no more than 20% of the canopy should be thinned at a given time and gaps larger than 20 m in diameter should be minimized to the extent possible. As mentioned in Table 12, Norway Maple trees can be girdled where they would not pose a safety hazard (e.g., in proximity to trails, rear yards, structures). Otherwise, mechanical cutting may be the preferred option for removal.

Recognizing the value of Norway Maple trees in parks and as street trees, Norway Maple trees adjacent to natural areas should be phased out, meaning that when they die, they should be replaced with native trees or a non-invasive exotic tree.

Norway Maple Management Zones

Norway Maple reproduce by seeds that disperse by wind as well as by animals. As animal dispersal cannot be quantified, wind dispersal distance is used to determine what is considered "adjacent" to a natural area. Dispersal distance of wind dispersed seeds (such as maple and pine seeds) is dependent on wind speed, initial height and the terminal velocity of the falling seed. Wind speed is higher in open areas than forested areas, causing dispersal distance to be much greater in open areas (Nathan et al., 2001). A study by Nathan et al. (2001) on seed dispersal in pine trees found that 99% of seeds fell within a dispersal distance of 41 m (mean of 7.5 m) in open areas compared to only 2.7 m (mean of 0.4 m) in dense forests. Pine and maple tree seed morphology is similar with samaras (seeds with a thin, flat wing created from ovary wall) being dispersed largely by wind (Ribbens et al., 1994; Wada and Ribbens, 1997; Nathan et al., 2001). Seed dispersal for two maple species (Japanese Maple (Acer palmatum) and Red Maple (Acer rurbrum) has been recorded up to 41.5 m (average of 11.6-12.5 m) in forested ecosystems (Ribbens et al., 1994; Wada and Ribbens, 1997).

Due to the comparable seed morphology of maples and to follow precautionary principles, it is recommended that no new Norway Maples be planted within a conservative 60 m from natural areas (Figure 3). This accounts for potential differences in dispersal distance between the listed species and Norway Maple as well as high wind conditions potentially increasing dispersal distances beyond those observed in the mentioned studies. High wind conditions are expected in areas "adjacent" to natural areas because these areas would typically be open, as they are outside of the forest/woodland and would consist of a variety of uses including manicured parkland, residential, industrial, commercial, or other infrastructure. This conservative measurement ensures an adequate distance for preventing seed dispersal into natural environments. It is important to note that the "phasing out" can occur on City property only (i.e., parkland, boulevards, etc.), as such public education/outreach is a key component to the success of this program as many private landowners have also planted Norway Maple for the same reasons as listed above.

Due to the potential for additional seed dispersal by water, it is also recommended that watercourses be treated in the same manner as natural areas in terms for the selective removal of Norway Maple over time. In this sense, Norway Maple should be removed from watercourse areas and phased out from adjacent areas.

6.4 Restoration as a Management Tool

6.4.1 Ecological Restoration

Ecological restoration is considered an important component of successful invasive species management. As non-native species are removed, there is often disturbance and/or unvegetated areas where regeneration will occur. Without active restoration, these areas are often recolonized by more aggressive non-native species, including invasive species. This section provides guidance on:

Figure 3. Management of Norway Maple illustrating an example of where certain recommendations should be applied relative to a natural area (NA).

- when to implement restoration,
- restoration plantings, and
- ongoing maintenance.

Ecological restoration is defined by the Society for Ecological Restoration as, "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER International Working Group, 2004). By applying ecological principles and implementing some techniques used in ecological restoration, the goal of reducing impacts of invasive species and enhancing the ecological integrity of the natural areas will be more attainable.

The purpose of using ecological restoration as part of the ISMP&IS is to suppress the re-establishment of invasive plants by increasing the diversity and abundance of native plant species. The objectives of planting native species are to:

- out-compete non-native and invasive species,
- enhance native species composition and ecological function of the natural area, and
- enhance ecological integrity.

6.4.2 When to Restore

Restoration is considered a control strategy and should be done in combination with other invasive species management techniques. The triggers for including native plant restoration as a method to control invasive plants will depend on the extent and intensity of soil disturbance (e.g., hand or mechanical pulling of saplings or herbaceous plants may disturb soil) and the presence and abundance of both native and invasive species (vegetation and seed bank).

Management efforts for both flora and fauna invasive species will result in a change in vegetation cover and perhaps microclimatic conditions in a natural area; for example:

- hazard tree removals after EAB infestation which will increase the amount of light penetrating to the understory and ground layer,
- soil disturbance resulting from use of machinery to cut trees or mechanically pull priority invasive saplings/shrubs, or
- extensive removals of understory or ground-layer invasive plants.

The primary considerations for determining when a site requires restoration after control measures are the size of the control area (large or small) as well as the presence/abundance of:

- native flora,
- priority invasive flora, and
- disturbed soil.

These three considerations are utilized in Table 14 to aid in deciding when restoration is appropriate. This evaluation is based on two invasive plant control area sizes: small (< 10 m^2) or large (> 10 m^2). There is no "medium" sized category as these areas would be treated the same as the large-sized disturbances. In this table, presence refers to the percent cover relative to other plant species in the control area post implementation of invasive species control. A group (native or priority invasive) may be considered abundant if cover is greater than 25%. Disturbed soils are those which have had the upper most layer of mineral soil stripped, graded, tilled, churned following vegetation removal, or compacted. The disturbed soil column refers to the presence of disturbed soil resulting from invasive species management, regardless of extent of disturbance. The restoration column indicates whether restoration is recommended in each case. Table 14 is a general guideline to assist in determining when native plant restoration may be appropriate; however, professional judgement as well as financial implications (e.g. cost of native plant restoration vs. ability to control other populations of invasive plants within the natural

Table 14. Guideline for deciding when to restore following removal of invasive plants considering abundance of native plants, presence of priority invasive plants and seed bank, as well as soil disturbance (Y=Yes, N=No).

Size of Control Area	Presence		Distrubed Soil	Restore
	> 50% cover of Native	Priority Invasive		
< 10 m²	Y	Y	Y	N
			N	
		N	Y	
			N	
	N	Y	Y	Y
			N	
		N	Y	N
			N	
> 10 m²	Y	Y	Y	Y
			N	
		N	Y	
			N	N
	N	Y	Y	Y
			N	
		N	Y	
			N	N

area) should be taken into account when determining if native plant restoration will be implemented.

From Table 14, general statements can be made regarding the need for restoration after invasive species control. Restoration is recommended for:

- Small (<10m2) areas where there are no native species present but there is an abundance of priority invasive species (regardless of soil disturbance).
- All large (>10m2) areas, except:
  - where there is an abundance of native species, no priority invasive species, and no disturbed soil, and
  - where there are no native species, no priority invasive species, and no disturbed soil.

6.4.3 Restoration Plantings

Restoration of an area following invasive plant control/removal will involve establishing a native plant community in place of the invasive plants removed. Table 15 provides guidance on what guild of species to plant (i.e. trees, shrubs, herbaceous and graminoid), the size of stock or if a seed mix is preferable, and density/spacing.

The type and mix of vegetation selected for restoration will vary depending on the size of the management area, soil moisture (e.g., upland, lowland, or wetland), slope, light, and canopy conditions (open or closed). Specific species compositions for each vegetation community should be developed by consulting various sources (refer to Appendix 5) and in consultation with a qualified ecologist.

When selecting native species for restoration in areas where invasive species have been removed, it is recommended that more robust and aggressive species be planted in order to outcompete regenerating non-native plants. Appendix 6 provides a list of native plant species that are recommended for restoration of managed areas in forested vegetation communities.

Note that cultivars are not acceptable in restoration plantings (e.g., cultivars of Red-Osier Dogwood (Cornus stolonifera) should not be used in restoration plantings). See Appendix 7 for a list of common invasive tree and shrub substitutions (i.e. misidentified as native) in nurseries. Use of native seed and stock of local genetic providence is encouraged for restoration purposes. Seed and stock collected locally contain genetic traits that have developed through long-term adaptations by the species to local micro-climates and conditions and therefore generally have greater survival success. The 6th Edition of the Native Plant Resource Guide for Ontario (Society for Ecological Restoration Ontario, 2011) includes information and sources of native planting materials in support of ethical and successful ecological restoration efforts in Ontario. This guide also includes a list of growers and suppliers of native plants and seeds.

6.4.4 Ongoing Maintenance of Restoration Plantings

All woody vegetation stock should be pre-pruned so that they do not require pruning after planting and so that all dead or broken material is removed. Watering and mulching are ongoing maintenance measures required for restoration plantings.

Mulching

It is recommended that the following maintenance guidelines for mulching be implemented at the time of planting:

1. Wood chip mulch must be applied to a depth of 15 cm at the base of a tree/shrub and extending in a 70 cm diameter circle around the stem of each plant.
2. Mulch must be pulled away from the immediate stem, in a donut-shaped profile, to prevent stem rot.
3. Coarse mulch is preferred to fine/ shredded mulch as it improves air and water circulation and does not become compacted.

Watering

It is recommended that the following maintenance guidelines for watering be adhered to following restoration plantings:

1. Each restoration area should be watered at the time of planting. Watering frequency will largely depend on precipitation and existing soil moisture conditions (i.e. watering may not be required in moist soils such as lowland forests or in wetlands).
2. The following guidelines shall be followed when watering:
   a. Water at least twice during the active growing season (April 15 to November 15 of each year) or as required during drier years.
   b. Apply water to the point where the soil in the upper 10 cm of the planting area is saturated; ensure that excessive runoff is avoided by applying water slowly to allow time for it to percolate down towards the root system of the tree or shrub.
   c. Watering shall take place at appropriate times, such that watering is not done following a rainstorm or when rain is forecast within 24 hours.

Deer Repellant

The high density of deer in the region poses a potential risk to the success of restoration projects through the browsing of newly planted vegetation. Deer repellant, such as Bobbex, may be used as a deterrent until the native vegetation is re-established. Additionally, using fencing or planting caliper trees may reduce impacts of deer browsing in areas of particular concern.

Monitoring

Inspection of the planted material should be completed within 2-3 years of installation. Monitoring will inform maintenance measures such as trimming competing vegetation around plantings, or adding mulch where needed.

Table 15. Considerations of planting for restoration of managed areas.

Type	Groups	Stock Type/Seed	Minimum Height of Stock	Density/Spacing	Notes
Trees: all can be planted in spring, Poplar and Birch may not do as well if planted in fall, evergreens should be watered thoroughly if planted in fall					
Coniferous	Pine, Spruce, Hemlock, Cedar, Common Juniper	BR or CG (fibre pot) or B&B	100 cm	1/20 m^2; 4-6 m spacing for pine/spruce/hemlock, 2-3 m for cedar	B&B and fibre pots best; spring best
Deciduous	Hickory, Oak, Basswood, Maple, Birch, Poplar, Cherry, Ironwood	BR or CG	100 cm	1/10 m^2; 2-3 m spacing	BR is best if available; spring best but some can be planted in fall
Shrubs: most can be planted in spring or fall, Willows should be planted in spring if possible					
Large	Blue Beech, Alternate-Leaved Dogwood, Serviceberry, Chokecherry, Willow, Witch Hazel	BR or CG (5 gallon)	120 cm	1/10 m^2; 2-3 m spacing	BR is best if available
Medium	Red-osier or Grey Dogwood, Elderberry, Viburnum	BR or CG (3 gallon)	60 cm	2/10 m^2; 1-2 m spacing	BR is best if available
Small	Currant, Rose, Raspberry, Blackberry, Bush Honeysuckle	BR or CG (1 gallon)	60 cm	4/10 m^2; 1 m spacing	BR is best if available
Herbaceous and Graminoid: late spring or early fall planting to avoid frost-heaving					
Forest	Sedges, Wildflowers, Ferns	4" or 1 gallon pots, plug or seed	n/a	Pots/plugs = 10 plants/1 m^2	Pots are best, plugs if available
Swamp		4" or 1 gallon pots			Plant where surface water levels fluctuate
Open upland	Sedges, wildflowers, grasses	4" or 1 gallon pots, plug or seed			Pots/plugs best in small areas (<100 m^2), seed in large (>100 m^2)
Open wetland		Plugs in small areas (<100 m^2), seed in large (>10 m^2)			Make seed ball and place on soil where surface water levels fluctuate or broadcast seed

BR = bare-root
CG = container grown, usually plastic
B&B = balled in burlap
FP = fibre pots (paper containers; plant is dug just before shipping and put into the fibre pot)

General Planting Guidelines

- Avoid freshly potted tree and shrub stock.
- Remove all plants from containers before planting.
- Plant at the root collar, not deeper or shallower.
- Straighten or prune circling roots carefully before planting.
- Spread roots of potted herbs and plugs at planting.
- Plant trees and shrubs in dormant season when possible, plant herbs when actively growing.
- Water after planting, especially herbs.

7.0 Management of Invasive Fauna

Native, Alien, Invasive
Forest insects and diseases in Canada are typically classified into three broad categories:

- **Native:** Indigenous species that have existed in Canada for thousands of years. Outbreaks occur periodically. Examples are Fall Cankerworm, Spruce Budworm, and Mountain Pine Beetle.
- **Alien:** Species introduced into Canada's forests within recent history. They are also referred to as "exotic," "non-native" and "foreign." Examples include EAB, Brown Spruce Longhorn Beetle, and Dutch Elm Disease.
- **Invasive:** Insects and diseases that spread beyond their known usual range.

(Natural Resources Canada 2016)

Invasive fauna are insect species that are considered to be invasive forest 'pests' (native or alien). By consuming trees and other plant material, forest insects can contribute to healthy change and regeneration in forest ecosystems (Natural Resources Canada, 2016). When infestations are so severe that they destroy or damage large areas of commercially, socially, or ecologically valuable forest, then these species are considered to be pests – regardless of whether they are native or alien.

Fauna monitoring is treated differently than flora monitoring in this report given existing regulations which dictate monitoring techniques and/or City protocol for the priority invasive species identified. Using an Integrated Pest Management (IMP) approach, the City of Mississauga's Forestry Section manages and monitors City-owned property for signs of new and existing species of insects that pose a threat to the environment. Forest pest insect management entails a comprehensive approach to understanding the pest problem, past and present, in order to predict the future and implement proactive approaches to managing them below an acceptable threshold. Key components that may be involved in an integrated approach to forest pest insect management are shown in Table 16.

Table 16. Components for consideration under Forest Pest Insect Management.

Component	Definition
Monitoring	• awareness of new CFIA regulated pests, • spatial distribution (landscape level & within tree) • time of year • rate • potential for spread
Identification	• taxonomy • life history • host range • native/exotic • population cycling
Damage	• part of tree affected (leaves, shoots, trunk, shoots whole or part of tree attacked) • effect of attack (death, slowed growth or reduced vigour)
Impact	• tree death • poor growth • poor aesthetics (shape or discolouration) • no regeneration • increased risk to public • reduced use of recreational areas
Natural Mortality Factors	• weather • birds • small mammals • other invertebrates

In support of existing City strategies, this report identifies a number of additional species for which the City should proactively monitor outside of the priority species list (Table 17), watching for signs and host symptoms that could be indicative of their presence. At the time of the production of this report, the known insect pest species of most concern present within the City are EAB, ALHB, and Gypsy Moth. Species that were at one time documented from within the City, but that are not necessarily known to be present at this time, are important to be aware of due to the cyclical nature of some insect infestations. Species that are currently not known within the City, but that could reasonably reach the City during the timespan of this plan (through to 2033) are also listed.

Emerald Ash Borer. Photo by North-South Environmental Inc.

Table 17 discusses the insect pest species that have been documented in the City in the past, present, and those that may potentially be encountered in the future. For each species, the following is provided:

- CFIA Regulated Species Status,
- preferred Ontario host trees,
- whether it attacks healthy trees,
- whether it kills healthy trees without other contributing factors (e.g., drought, wounds),
- infestation cycles,
- when the species was last documented in City,
- North American distribution, and
- signs and symptoms of infestation.

The information contained within Table 17 can be used to inform preliminary monitoring efforts in the absence of applicable legislation or guidance from the appropriate authorities. City tree inspectors may also use the table as reference when identifying signs and symptoms of invasive insect pests when undertaking EDRR. In particular, for species that have been documented in the past, the infestation cycles are important to note (for species with generally cyclical infestations) in order to predict potential years in which the species may be re-encountered.

Further to Table 17, each of the species identified as priority species in this report (i.e., EAB, ALHB, and Gypsy Moth) are discussed in the context of the City's current management approach. Priority invasive fauna identified are either regulated by the CFIA (i.e. EAB, ALHB) or already managed by the City (i.e. Gypsy Moth). As such, management triggers are defined in policy or existing protocol. Current management approaches and management triggers are discussed in the following sections, but may change from time to time based on the current science.

Table 17. Insect pest species that have been documented in the City in the past, present, and those that may potentially be encountered in the future. (* indicates species that have been introduced to Canada; **α** indicates regulated by CFIA).

Common Name	Host Trees (bold = preferred host)	Attacks Healthy Trees (Y/N)	Kills Healthy Trees (without other contributing factors) (Y/N)	Infestation Cycles (years)	Last Documented in City	North American Distribution	Signs & Symptoms	Comments
Emerald Ash Borer [1] (Agrilus planipennis)* α	**Ash**	Y	Y	None known	Current	Southern Ontario from Lambton County north to Grey County and east to Renfrew County and Ottawa. Infestations spreading through Manitoulin Island, and Sault Ste. Marie, east of the City to St. Joseph's Island in Algoma District Currently reaches as far north as St. Lawrence in Quebec, detected as far south as Texas and Louisiana, to the coast of the Atlantic and as far west as Colorado	• Thinning crown at top • Premature leaf drop • Branch dieback in the crown • Galleries girdle the ash trees and foliage will wilt or turn yellow • Shallow meandering "S" shaped tunnels under the bark with abrupt turns • Adults leave "D" shaped exit holes 4 to 5mm across on the bark of infected trees • Leaf notches caused by adult borer feeding. • Frass (refuse left behind by boring insects) or sawdust will be evident in tunnels • Epicormics shoots (growing from a previously dormant bud) on branches and trunk • Other signs include damage caused by woodpecker or squirrel feeding activity. Symptoms of EAB infestation include epicormic shoots, bark deformities, heavy seed production, yellow foliage, dead branches (in excess of normal levels), and a thinning canopy.	• City of Mississauga Emerald Ash Borer Management Plan (2012) directs activity • Introduced from Asia

1 Ministry of Natural Resources and Forestry, 2016

Common Name	Host Trees (bold = preferred host)	Attacks Healthy Trees (Y/N)	Kills Healthy Trees (without other contributing factors) (Y/N)	Infestation Cycles (years)	Last Documented in City	North American Distribution	Signs & Symptoms	Comments
European Gypsy Moth[2] (*Lymantria dispar v. dispar*)*α	Alder Apple Aspens Cherry Basswoods Beech Birch Hawthorn Maples **Oaks** Willows	Y	Y	Unconfirmed	Current	Found throughout southern Ontario, New Brunswick, Nova Scotia, and southern British Columbia and across the eastern and central United States.	• Larvae chew holes in leaves or consume entire leaf • In late July beige spongy egg masses can be observed on the trunks and branches of infested trees as well as on various surfaces (buildings, signs, logs, rock piles, etc) in the surrounding area • During severe outbreaks, trees and shrubs are completely defoliated over large areas; despite the trees' ability to produce a new crop of leaves over the summer, the damage causes significant growth loss and eventually tree mortality with repeated complete defoliation over 3-5 years • Understory shrubs and plants may also be affected	• Species currently spreading north and west within the distribution of oak in Ontario. • No official management plan-Annual surveys used to inform the following years management. • Each population varies annually and fluctuates with local conditions. • Introduced from Europe into North America in mid-1800s. • European Gypsy Moth does well with mild winters (high egg survival) and dry springs (Entomophaga maimaiga fungus, a highly virulent fungal pathogen of the Gypsy Moth[3], thrives under moist conditions)

2 Ministry of Natural Resources and Forestry, 2016
3 Theodore and Weseloh, 1990

Common Name	Host Trees (bold = preferred host)	Attacks Healthy Trees (Y/N)	Kills Healthy Trees (without other contributing factors) (Y/N)	Infestation Cycles (years)	Last Documented in City	North American Distribution	Signs & Symptoms	Comments
Asian Long-horned Beetle[4] (*Anoplophora glabripennis*) *α	Birch Elm Goldenrain Tree Hackberry Horsechestnut Katsura Lilac London Planetree **Maples** Mountain Ash Poplar Sycamore Willow	Y	Y	None known	2013 (Monitoring confirms eradication as of June 2020)	Toronto and Vaughan (2003): infestation declared eradicated April 2013 after 5 years of surveys found no beetles/infested trees Mississauga and Toronto (2013): infested trees near Lester B. Pearson International Airport and susceptible trees within 800 m were removed 2013-2014 to eradicate infestation. Declared eradicated in June 2020.	• Tree starts to die from top down; leaves wilt, canopy appears sparse • Pockmarks on tree trunks and branches • Round exit holes (1.5 - 2 cm diameter) • Coarse saw dust • Frass • Early fall leaf colouration • Running sap • Oviposition pits • Galleries and tunnels under the bark	• Management direction from CFIA • Introduced from Asia
Fall Cankerworm[5] (*Alsophila pometaria*)	Black Oak Crab Apple Manitoba Maple Red Oak White Oak	Y	N	Periods of abundance every 10-15 years	2020	Widely distributed throughout southern half of Alberta, Saskatchewan, Manitoba	• Larvae chew small holes in the developing leaves, eventually leaving only large leaf veins and midribs	• Greater than three years of severe defoliation could cause tree mortality • Lifecycle is one year • Monitoring using sticky bands around tree trunks
Spring Cankerworm[6] (*Paleacrita vernata*)	Ash Elm Maples	Y	N	Periods of abundance every 10-15 years	Unconfirmed	Widely distributed throughout southern half of Alberta, Saskatchewan, Manitoba	• Larvae chew small holes in the developing leaves, eventually leaving only large leaf veins and midribs	• Greater than three years of severe defoliation could cause tree mortality • Lifecycle is one year • Monitoring using sticky bands around tree trunks

4 Ministry of Natural Resources and Forestry, 2016
5 Natural Resources Canada, 2015
6 Natural Resources Canada, 2015

Common Name	Host Trees (bold = preferred host)	Attacks Healthy Trees (Y/N)	Kills Healthy Trees (without other contributing factors) (Y/N)	Infestation Cycles (years)	Last Documented in City	North American Distribution	Signs & Symptoms	Comments
Previously Documented in Mississauga								
Fall Webworm (*Hyphantria cunea*)	Birch Cherry Crab Apple Hickory Walnut	Y	N	None known	Unknown	Throughout North America to the northernmost limit in southern Canada at latitude 50–55° (only excluding the most northern region of Ontario)	• Silk tents on trees in the fall • Defoliator feeds on leaves of plants (older caterpillars leave petiole)	• Negatively impacts aesthetics • Consecutive years of moderate-high defoliation can impact tree health over time—rare occurrence because of natural parasitoids
Two-lined Chestnut Borer[7] (*Agrilus bilineatus*)	**Bur Oak** Red Oak, White Oak	N	N	None known	Unknown	Found in Canadian maritime provinces, west to the Rocky Mountains, and south to Florida and Texas	• Foliage wilts from the top downward, turns brown, and usually remains on the branches after dieback for about one year • Emerge through "D" shaped holes in the bark • Meandering tunnels in the cambium and phloem	• Kills stressed trees
Bronze Birch Borer[8] (*Agrilus anxius*)	**Birch**	Y	N	None known	Unknown	Present across birch distribution in North America	• Thinning crown • Discolouration of the foliage • Premature leaf drop • Crown branch dieback • Winding galleries between bark and wood, usually filled with packed, digested sawdust-like borings • Raised welts on the bark of branches and tree trunk • Sap flows on the trunk near larval tunnel entry holes and "D"-shaped adult emergence holes on the branches and trunk	• Kills stressed trees, especially in urban areas
Pine Shoot Beetle[9] (*Tomicus piniperda*) *α	**Pines**	N	N	None known	Unknown	In the United States it is found in the northeastern and north central states. In Canada, it occurs in Ontario and Quebec.	• Bent, yellow and red shoots • Dead shoots on the ground from previous year with pith removed • Presence of boring dust (frass) on stems • Tunnels 2-10 cm in length dug inside shoots • Resin exudations at the insect entry holes	• Introduced from Europe

7 Natural Resources Canada, 2015
8 Natural Resources Canada, 2015
9 Natural Resources Canada, 2015

Common Name	Host Trees (bold = preferred host)	Attacks Healthy Trees (Y/N)	Kills Healthy Trees (without other contributing factors) (Y/N)	Infestation Cycles (years)	Last Documented in City	North American Distribution	Signs & Symptoms	Comments
Forest Tent Caterpillar[10] **(*Malacosoma disstria*)**	Aspens Birch **Sugar Maple** **Oaks**	Y	Y	10-12 years (infestation lasts 3-6 years)	2005/2006	Across North America	• Defoliator feeds on leaves of plants • Sustained heavy infestation results in growth reduction and branch killing	• Tree mortality exemplified if trees are suffering from other stresses
Potential to be Documented in Mississauga								
Hemlock Woolly Adelgid[11,12] **(*Adelges tsugae*)* α**	**Eastern Hemlock** Spruce	Y	Y	N/A	N/A	Much of the Great Lakes St. Lawrence region, as far south as Tennessee, but only recently discovered in Ontario Has been documented in Etobicoke (2012), Niagara (2013 &2019) and Wainfleet (2019) Found along west coast and along the Rocky Mountains	• Immobile, white woolly masses at the base of needles on undersides of hemlock twigs • Trees that have been impacted for year will also display off-colour needles, often with a grayish-cast; thinning crowns, premature needle loss	• In Canada only Eastern Hemlock is vulnerable when attacked • Surveyed for in 2013 and 2016 in Mississauga, with none observed • Introduced from Asia
White Pine Weevil[13] **(*Pissodes strobi*)**	Fir **Pines** Spruces	N	N	None known	N/A	Southern Canada and northern United States up to 600 north (includes all of Ontario) The following Canadian ecozones; Pacific Maritime, Montane Cordillera, Boreal Plains, Boreal Shield, Mixed Wood Plains, and Atlantic Maritimes	• Terminal shoot is attacked, wilts, bends over, and turns brown • Crooked, fork • Primarily an aesthetic problem in urban areas affecting tree growth and shape	• Primarily an aesthetic problem in urban areas

10 Ministry of Natural Resources and Forestry, 2016
11 Canadian Food Inspection Agency, 2015 & 2020
12 Natural Resources Canada, 2014
13 McGauley, B. H. and C. S. Kirby, 1991

Common Name	Host Trees (bold = preferred host)	Attacks Healthy Trees (Y/N)	Kills Healthy Trees (without other contributing factors) (Y/N)	Infestation Cycles (years)	Last Documented in City	North American Distribution	Signs & Symptoms	Comments
Oak Skeletonizer[14] **(*Bucculatrix ainsliella*)**	Oaks	Y	N	None known	N/A	Throughout range of Oak in Ontario, Quebec, British Columbia, and eastern United States	• Weakens trees through extensive defoliation • Thinning crowns & damaged leaves • "initially the larvae mine the leaf causing blisters and later skeletonize the leaf causing discoloured and transparent blotches"	• Occasionally cause complete defoliation (primarily an aesthetic problem in urban areas) • Repeated defoliation through successive years can decrease growth and increase susceptibility to diseases and other insects
Willow Leaf Beetle[15,16] **(*Plagiodera versicolora*)** *	Poplar Willow	Y	N	None found	N/A	Southern Canada, eastern United States, and Alaska	• Holes and notches in the leaves • The larvae skeletonize the leaves, feeding on both sides of the leaves and eating the tissue between the veins • With heavy infestation leaves may turn brown	• If infestation occurs 2-3 years in a row, it could be serious to the health of the tree, especially trees that are not well established • Introduced from Europe
Elm Leaf Beetle[17] **(*Xanthogaleruca luteola*)** *	**Siberian Elm** Elm	Y	N	None found	N/A	Eastern Canada and throughout most of the United States	• Skeletonization of the foliage, upper leaf surface and veins are left intact • Partial to complete defoliation	• Severe defoliation may weaken a tree, increasing susceptibility to other insects and diseases (e.g., Dutch elm disease) • Introduced from Europe
Asian Gypsy Moth[18] **(*Lymantria dispar (var. asiatica/ japonica/ albescens/ umbrosa/ postalba)*)* α**	Alder Apple Birch Cherry Hawthorn Beech Maple **Oak** Poplar Willow	Y	N	None found	N/A	Incursions have occurred around Canadian ports[19]; however, it is not yet considered established in Canada. It may become established in eastern North America from introduction by shipments from Asia.	• Holes in leaves, leading to defoliation • Crown dieback	• Severe defoliation can reduce tree growth and predispose trees to attack from other insects and diseases. • Four successive years of defoliation can cause mortality, especially in weakened or stressed trees

14 Burns, E. and C. Blaser, 2012
15 Cornell University, 2016
16 Murray, T., Nendick, H., Moisset, B., Quinn, M., and V. Belov, 2006
17 Hoover, G. A., 2001
18 Canadian Food Inspection Agency, 2015
19 Canadian Food Inspection Agency D-95-03, October 2013

7.1 Priority Species

7.1.1 Emerald Ash Borer

Management Approach

While population densities likely vary across the landscape, EAB is considered to be ubiquitous throughout the City of Mississauga. Even if certain areas are not presently showing signs of infestation, there are no viable control measures to slow or prevent the spread of EAB infestation in Mississauga.

The City of Mississauga has produced a formal EAB Management Plan (Marchant, 2012); this management plan represents the most current scientific information and regulatory requirements as of January 1, 2012. The report recognizes that a degree of latitude is required with respect to predicting its impacts, population development, and the overall effectiveness of the management options. The ISMP&IS generally reflects the current management approach in the City, but also incorporates the most current best management practices, scientific evidence, and regulatory requirements.

One update to note in particular given the progression of the spread of EAB in the City; EAB population monitoring and surveillance efforts (e.g., detection and delimitation surveys, branch sampling), which were previously intended to identify new infestation locations and determine EAB population densities, are no longer necessary. Instead, the condition of individual Ash trees and groups of Ash trees should be monitored on a regular basis to determine if changes to management approaches or timing of management are necessary. The City should continue to use previously developed Ash street and park tree inventories to guide Ash tree condition assessments, and should use the information from those findings to determine what management options should be implemented and when. These monitoring efforts will need to continue until virtually all actively-managed, non-treated Ash trees are removed and for as long as trees continue to be treated with stem injection.

Management Triggers

EAB management has been formally underway in Mississauga since Council approved the EAB Active Management Plan in 2012. Since EAB was first discovered in Mississauga in 2008, and through implementation of this program, the City has undertaken the proactive and reactive removal of thousands of EAB-infested and susceptible Ash trees, and the injection treatment of over 1,000 trees with TreeAzin™, a systemic insecticide. Treatment has been limited to trees displaying early signs of EAB infestation. Treatment has been discontinued on trees when no longer deemed effective, generally after several years. This process has delayed the timeline for removal and replacement of the trees, and resulted in a more distributed and manageable workload.

Eradication of EAB is not possible, and management of the pest itself is currently not considered a viable option due to its ubiquitous presence across the entire City of Mississauga and beyond. Therefore, EAB management in the City of Mississauga focuses on:

1. The protection of selected specimen Ash trees through stem injections; and,
2. The removal of susceptible, infested, and dead trees which may pose a safety risk to the public or other values.

There are no additional triggers for management, as active management is already underway. However, specific criteria can be applied to guide whether and how individual Ash trees, or groups of Ash trees, are managed. These criteria are described below and presented in Table 18.

Criteria for Management

Three management options are available for Ash trees in EAB-infested areas, including:

1. stem injection of systemic insecticide,

2. removal, and
3. the 'Do Nothing' approach, whereby trees are left to succumb to infestation and are not actively managed.

Notably, the City of Mississauga no longer supports the use of stem injection of a systemic insecticide in new trees meeting the criteria for management described below. Healthy trees that have previously received systemic insecticide treatment will continue to receive the treatment for as long as the criteria for this type of management are met.

Determining the appropriate management option requires that individual trees, or groups of trees, be assessed for several criteria. These criteria include:

- signs or symptoms of EAB infestation,
- percentage of canopy dieback,
- tree size, measured as diameter at breast height (DBH),
- tree location,
- risk rating, and
- the benefits provided by the tree.

These criteria, and how they can be used to determine the appropriate management actions, are described in greater detail below.

Signs and symptoms of EAB infestation – Trees displaying visually-evident signs and symptoms of EAB infestation are generally not suitable for insecticide injection. Experience and research suggest that trees exhibiting signs or symptoms are often heavily infested and that their vascular systems are sufficiently compromised that translocation of insecticide is disrupted and ineffective. A comprehensive description of signs and symptoms of EAB can be found in "A Visual Guide to Detecting Emerald Ash Borer Damage" (de Groot et al., 2006) and Table 17 of this report

Percentage of canopy dieback – As EAB infestation progresses, Ash trees typically exhibit increasing levels of canopy dieback or decline. Dieback can be expressed as a percentage:

- dieback rating of 0% = Ash tree has a full leaf canopy
- 100% dieback = no live leaves are present during the typical leaf-on season

Guidance provided by BioForest Technologies Inc., the distributor of TreeAzin™ systemic insecticide, suggests that Ash trees exhibiting canopy dieback of 30% or more (i.e., 70% canopy fullness or less) are unsuitable for stem injection treatment (BioForest Technologies Inc., 2013). Such guidance is likely overly optimistic, as experience (e.g., Roberts , 2014) suggests that the likelihood of successful long-term protection of trees exhibiting even 10%-20% EAB-induced canopy dieback at the time of initial protection efforts is low. Therefore, Ash trees in the City of Mississauga exhibiting greater than 20% canopy dieback should not be considered as qualified for stem injection treatment. Trees exhibiting 10%-20% should also be carefully assessed to determine whether continued stem injection is likely to be successful and merits the resource expenditures involved.

Tree size (DBH) – Diameter at breast height (DBH, or 1.4 m above grade) is the most common method to determine and denote tree size. Typically, small Ash trees are not considered suitable for insecticide injection due to the relatively high cost of treatment versus tree replacement, significant potential for wounding of small trees during injection, and questionable treatment efficacy. As a general rule, trees less than 20 cm DBH are considered unsuitable for injection treatment as part of a municipal EAB management program.

Tree location – The location of an individual Ash tree or groups of Ash trees is an important criterion in determining appropriate management responses. Trees along streets and in actively-managed park areas are generally considered suitable candidates

Table 18. Decision matrix for Emerald Ash Borer and Ash tree management options.

Management Options	Decision Criteria[1,2]					
	EAB Infestation Signs/ Symptoms	Canopy Dieback (%)	DBH (cm)	Tree Location[4,5]	Risk Rating	Benefit
Injection[3]	None	< 20%	> 20 cm	Street or Manicured Park	Low	Demonstrated benefit to tree retention (e.g. streetscape)
Removal	Any	> 20%	< 20 cm	Street, Manicured Park, Woodland Edge, Trails[5]	Moderate or Higher	Removal of hazard tree, no ongoing management
No Action	-	-	-	Woodland Interior	-	-

1. Ash tree must meet all conditions for the 'Injection' management option criteria to qualify for insecticide treatment. Applies only to trees that have previously received injection. The City will not be undertaking any injections for new trees.
2. Ash tree qualifies for 'Removal' management option if it meets any conditions for the 'Removal' management option criteria but must be located on woodland, edge, or trail.
3. Ash trees located on lands not included in criteria may qualify for 'Injection' or 'Removal' based upon other criteria.
4. Ash tree is considered a 'trail' tree if it is located within 1.5x or less of potential tip-out distance of City-managed woodland trail.
5. In accordance with International Society of Arboriculture (ISA) Best Management Practices for Tree Risk Assessment (Smiley et al., 2011)

for systemic insecticide injection, as maintaining the aesthetic, shading and other benefits provided by these trees merits the associated resource expenditures. Ash trees located in woodland edges, along actively-managed trails, or in other areas where there is potential for tip-out of failed trees or tree parts may pose a risk to human health or property, also require active management. However, management in these scenarios should generally be restricted to removal.

Trees located in woodland interior areas, where human activity is low and there is low risk to human safety or property, do not generally require active management and can be allowed to succumb to EAB-induced mortality and fall as they decay. Allowing these trees to remain is important ecologically as snags provide habitat for many wildlife species. It should be noted, however, that woodland management and restoration objectives may necessitate the active management of such trees should they be considered as impeding such objectives.

Risk rating – Every Ash tree which may be actively managed should be visually assessed to determine its risk rating prior to selecting the appropriate management action. Risk should be rated in accordance with the "International Society of Arboriculture (ISA) Best Management Practices for Tree Risk Assessment" (Smiley et al., 2011), the companion best management practice publication to the "ANSI A300 Part 9: Tree, Shrub, and Other Woody Plant Management – Standard Practices (Tree Risk Assessment Tree Structure Assessment)" (Tree Care Industry Association Inc., 2011) industry standard for tree risk assessment. EAB-induced mortality can increase the risk of whole-tree or component part failure of Ash trees (Persad et al., 2013). However, tree risk should be evaluated for the tree's present condition, as the tree's current state will determine the appropriate management option. Generally, Ash trees posing elevated risk levels should be removed, while low-risk trees can be treated with stem injection if they meet other criteria for this management option.

Benefits – Ash tree management decisions must weigh the benefits of retaining individual trees against cost, complexity, uncertainty and other factors associated with stem injection treatment. While every tree in the forest provides some measure of benefits through microclimate amelioration, air quality improvement, and carbon sequestration, trees to be protected through continued stem injection treatment should provide demonstrable and significant benefits beyond those general environmental services. Examples of such benefits include aesthetics (e.g., streetscape framing) or shading.

The above-noted criteria should be used to assess individual Ash trees or groups of Ash trees to determine the appropriate management option. As described in Table 18, Ash trees must fulfill a relatively conservative set of conditions to qualify for continued protection through stem injection treatment. This will ensure that the significant resources required to inject trees are expended only where there is a high likelihood of long-term treatment success and where it is sensible to retain the treated trees for the long-term. Conversely, if Ash trees meet any of the conditions for removal, they are considered to be disqualified from injection treatment. It should be noted, however, that 'exceptional specimen' trees, which may be determined as such for a variety of reasons, can still qualify for continued treatment even if they do not fulfill one or more of the treatment management option criteria and conditions. For example, a large, healthy and low-risk Ash tree situated along a trailside in a woodland setting would normally be disqualified from injection due to its location. However, if it was considered an exceptional specimen due to its health, size, or other factors, such a tree may be considered for continued protection.

It should also be noted that factors outside of the listed criteria may also influence management options. For example, trees may be treated to delay mortality and to enable tree removal efforts to be spread over a longer time period.

7.1.2 Asian Long-horned Beetle

Management Approach

Early detection and rapid response is the recommended approach for addressing future infestations of ALHB. ALHB was first detected in the Malton area of Mississauga in 2013 following previous outbreaks in Toronto and Vaughan in the early 2000s. Since 2013, the City has worked with the Canadian Food Inspection Agency (CFIA) to control and monitor ALHB.

After 5 years of intensive monitoring with no detection of the signs, symptoms or live specimens of ALHB, the CFIA declared that ALHB has been successfully eradicated from Mississauga and nearby Toronto. Active and intensive monitoring was critical to enabling early detection and successful eradication of ALHB in Mississauga. Monitoring surveys were based on the survey protocols of the CFIA (Ric et al., 2006) and included ground-based visual inspection using binoculars and, for larger trees or those near the leading edge of the infestation, aerial inspection using ladders, bucket trucks and/or tree climbers (depending on tree size and location).

Management Triggers

The 2013 Malton detection triggered a rapid response from the CFIA, the City of Mississauga and the City of Toronto. The CFIA established an approximately 20 km^2 regulated area as part of its responsibility for the control and eradication of invasive insects under the Plant Protection Act. Altogether, approximately 7,500 trees of suitable host species were removed from the nearly 20 km^2 regulated area, including thousands on Mississauga-owned lands such as Paul Coffey Park (previously Wildwood Park).

This sizeable response by numerous agencies clearly demonstrates that, currently, the presence of a single positive identification of a live ALHB or positive signs of infestation (Table 17), are sufficient to trigger management action. Currently, ALHB management is primarily the responsibility of the CFIA, with municipalities acting

Table 19. Asian Long-horned Beetle zones in Toronto as established by the Canadian Food Inspection Agency.

Zone	Definition	Host Species Action
Primary	The infested area itself	Suitable host species within the first three zones removed and chipped.
Secondary	Up to 400 m beyond the last known infested tree	
Tertiary	400 m to 800 m beyond the Primary Zone	
Protection	Up to 2.4 km beyond the Primary Zone	On-going monitoring

in a supporting role by providing personnel, equipment and other resources as necessary to detect, monitor, and manage ALHB infestation. As such, the agency may choose to establish different thresholds and triggers for management in the future, should circumstances change or new detections be made.

ALHB management is currently intended to eradicate (not control) the pest. Therefore, the only ALHB management option available is the removal and proper disposal of infested trees and suitable host trees within a prescribed buffer area around the site of infestation (see Section 9 for biomass disposal methods).

Criteria for Management

Any positive identification of ALHB infestation necessitates immediate and intensive management action, as complete eradication is currently the sole ALHB management objective across Canada.

In the event of future positive identifications, the extent and intensity of ALHB management actions (specifically, removal of infested trees and suitable host species within a prescribed area) are likely to be determined by the CFIA under the authority of the Plant Protection Act and other enabling legislation and regulations, and the City of Mississauga will likely be expected to provide management support as it has in the past.

To control the first Canadian ALHB infestation, which began in 2003 in Toronto and Vaughan, the CFIA established four distinct zones around known infested areas (Table 19).

7.1.3 Gypsy Moth

Two races of Gypsy Moth, European Gypsy Moth and Asian Gypsy Moth (Table 17) have the potential to impact trees in the City of Mississauga. The Asian Gypsy Moth is of greater concern because it has a broader host range and female moths can fly, however this species has not yet become established in eastern North America. Given that detection and management for both moths are similar, further discussion and recommendations apply to both.

Management Approach

The City of Mississauga actively monitors and manages Gypsy Moth populations. Management strategies are based on an adaptive Integrated Pest Management approach (Section 7.2) that relies on the best and most current information available. Recommended components of the IPM approach for Gypsy Moth are listed in Table 20.

Population monitoring programs should coincide with the Gypsy Moth's life cycle, in accordance with Natural Resources Canada (Nealis and Erb, 1993) recommendations. The recommended monitoring/sampling timing schedule is presented in Table 21, below.

Egg mass surveys and egg mass scraping

Egg masses can be sampled with visual surveys and used to estimate population size and make predictions about defoliation levels in the following season. Egg mass scraping can be conducted in conjunction with surveys or following surveys to supplement control where warranted.

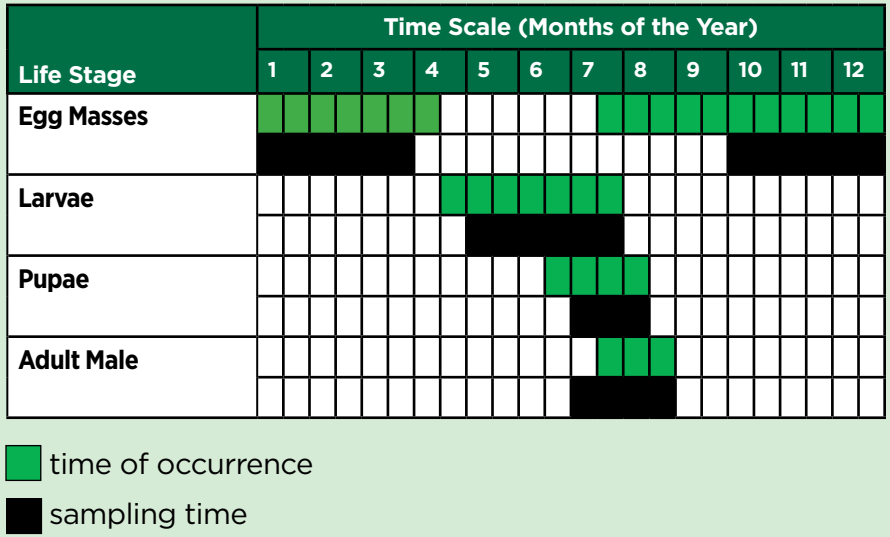
Larval and pupal observations

Larvae and pupae can be surveyed in conjunction with other

Table 20. Integrated Pest Management approaches recommended for Gypsy Moth management.

IPM Method	Component
Mechanical Control & Monitoring	• Egg mass surveys and egg mass scraping • Larval and pupal observations • Live adult trapping • Defoliation monitoring
Chemical Control	• Ground sprays using Btk • Aerial sprays using Btk • Tree injections using TreeAzin®
Public Engagement	• Citizen education and engagement

Table 21. Approximate seasonal occurrence of various life stages of the Gypsy Moth and optimal sampling times (adapted from Nealis and Erb, 1993; Speir, pers. comm., 2017).



time of occurrence

sampling time

trapping and control measures (i.e., burlap bands). Similarly, adult moths can be surveyed via the use of pheromone traps. These observational methods can be used as part of a presence/absence monitoring program to identify populations in new areas. Because these methods actively concentrate/attract gypsy moths they are inherently biased and not recommended to determine accurate population estimates.

Live adult trapping

Live trapping involves the installation of burlap bands on trees and/or the installation pheromone traps. These methods serve to attract and/or concentrate Gypsy moth larvae, pupae or adults. Trapping serves as a control method (i.e., trapped individuals are usually killed), but due to the limited effectiveness in controlling even small populations and the required effort to check and install traps and burlap, live trapping methods are not recommended for complete control. These methods can be used to supplement control in high priority areas where additional Gypsy Moth treatment is occurring within the same year(s).

Defoliation monitoring

In addition to population monitoring, defoliation estimates may also be desirable to calibrate survey and forecasting methods or to understand the extent of infestation (Tables 22 and 23). Defoliation estimates can be conducted on an as need basis. Defoliation monitoring can provide valuable information regarding the efficacy of treatments in controlled areas, accuracy of predictions in areas with defoliation forecasts, verification of population levels, and verification of information provided by the public.

More accurate results can be obtained by leaf presence/absence counting on pruned branches (see Nealis and Erb, 1993, pg. 15), although this time-consuming and moderately destructive method is not recommended for widespread implementation. During periods of widespread and large-scale infestation and defoliation, aerial surveys may provide useful information.

Chemical Control

In addition to manual control methods listed above, tree injections and ground sprays can be implemented to control Gypsy Moths where trees are predicted to be at high risk of defoliation (see management triggers below). TreeAzin® is a botanical injectable and is injected in a controlled way into the sapwood of a tree. Treated trees are protected from Gypsy Moth defoliation during the year it is injected. Ground sprays involve the use of products containing the active ingredient *Bacillus thuringiensis* subspecies *kurstaki* (Btk). Heavily infected trees can be sprayed from the ground by licenced operators using a controlled mechanism such as a pressurized hand-held hydraulic sprayer.

Aerial sprays can be conducted using Btk in response to large scale, widespread increases in Gypsy Moth populations (see management triggers below) and circumstances that preclude other IPM measures to be effective at keeping populations within manageable thresholds.

Public Engagement

Increased public awareness has the potential to identify emerging areas of concern that are outside regularly monitored areas. Mississauga residents can be engaged in reporting Gypsy Moth observations in their area, controlling Gypsy Moths on their own properties, and educating others in their communities. Engaging residents in Integrated Pest Management on their own properties can increase Gypsy Moth population control across the City.

History of the City of Mississauga's Gypsy Moth Management

The City has taken an adaptive management approach to Gypsy Moth control to ensure effective management of changing populations. Program highlights are listed below:

- 2003: City begins monitoring for Gypsy Moths
- 2006: Aerial Spray
- 2007: Aerial Spray
- 2012: City adopts an IPM approach to managing Gypsy Moths, monitoring program is formalized, hanging of pheromone traps and burlapping of trees begin
- 2015: Tree injections are first included in IPM and continue in select years moving forward
- 2018: Aerial Spray
- 2020: IPM includes egg mass scraping, ground sprays, tree injections and monitoring

Management Triggers

The City of Mississauga manages Gypsy Moth through the implementation of a variety of IPM and Plant Health Care (PHC) approaches. However, the widely-varying and somewhat cyclical population patterns of Gypsy Moth require that the nature and intensity of management activities are determined on the basis of the previous year's population monitoring results. Egg mass counts are the most widely used indicators to predict population level and defoliation potential and determine the necessary management approaches. In Mississauga, annual egg mass surveys are conducted on street trees and in parks and natural areas.

Generally, management triggers are determined by management objectives which could include: foliage protection, prevention of tree mortality and/or nuisance abatement. The link between egg mass density and subsequent defoliation is used as a guide to determine when and where treatment is needed. The management triggers noted below were those practiced by the City at the time this report was prepared, however it is important to recognize that the Gypsy Moth IPM program is adaptive. Therefore modifications to management triggers are possible and advised to address situations where other stressors are present that may predispose trees to mortality or where particularly high value/specimen trees are present (see Considerations for Management and Table 24).

Table 22. Gypsy Moth defoliation predictions based on egg mass densities per hectare, and associated management impacts applied to street trees.

Egg Mass Density (Total EM/ha)	Defoliation Forecast	Defoliation Forecast Range (%)	Management Impacts
0	None	0 to 5	None
1 to 1250	Light	6 to 25	< 20% Defoliation
1251 to 3750	Moderate	26 to 65	Nuisance and Aesthetics; Noticeable Defoliation
3751 to 5000	Heavy	66 to 90	Wildlife and Recreation; Growth Loss
> 5000	Severe	91 to 100	

Thresholds adapted from USDA defoliation prediction model developed by Gasner et al. 1985.

Table 23. Gypsy Moth defoliation forecasts for Woodlands based on egg mass densities per tree.

# of New Egg Masses Per Tree	Defoliation Forecast	Defoliation Forecast Range (%)
0	Nil	0 to 5
1 to 10	Light to Moderate	6 to 25
11 to 50	Moderate to Severe	26 to 65
> 51	Severe	> 65

Thresholds adapted from USDA defoliation prediction model developed by Gasner et al. 1985.

Street Trees

For street trees, visual surveys and active Gypsy Moth management are predominantly undertaken on oaks (*Quercus*). In order to assess the Gypsy moth population across the City, the area has been subdivided into 1 km grids and each year a subset of grids is sampled based on multiple factors including previous presence of Gypsy Moth, high concentration of host trees (oaks), etc. Within each grid a minimum of 3 plots are established to determine egg mass density and egg mass size. Egg mass density per hectare is a standard measure for temporal and spatial comparisons of populations and is used to forecast defoliation for street trees within each grid square in the following year. The defoliation forecast levels for grid squares are outlined in Table 22. In general, areas forecasted to have heavy or severe defoliation are considered for treatment. Within treatment areas, individual trees are selected based on the number of egg masses per tree. Generally, trees with more than 50 observed egg masses per tree are considered.

Woodland Trees

In woodlands, trees of all species are visually surveyed for egg masses. The average egg mass density per tree is calculated for each surveyed woodland and used to forecast defoliation, determine associated management impacts, and plan management approaches. The defoliation forecast levels for woodlands are outlined in Table 23. Woodlands where the defoliation forecast is expected to be moderate or greater are subject to increased monitoring and, based on monitoring results, potentially identified for management. Within woodlands selected for management, individual trees are selected based on the number of egg masses per tree. In general, trees with more than 50 observed egg masses per tree are considered. Other trees within these woodlands with forecasts of moderate or greater defoliation may be managed using burlap installation or pheromone trapping to supplement more intensive control measures.

Considerations for Management

There are multiple considerations when determining where Gypsy Moth management will occur. The management triggers outlined above can inform management decisions, however thresholds can be altered based on considerations specific to each situation. In addition to the defoliation forecast, the following considerations presented in Table 24 (adapted from USDA's "The Gypsy Moth: Research Towards Integrated Pest Management" (Doane and McManus, 1981) and Forestry Canada's "Sourcebook for Management of the Gypsy Moth" (Nealis and Erb, 1993) should also be considered when determining whether intensive management actions should be implemented. Additional considerations have been added based on learned experiences and can continue to be added or developed over time.

Table 24. Considerations for when to implement intensive management of Gypsy Moth in areas where heavy to severe defoliation is forecasted for street trees, and moderate or greater defoliation is forecasted in woodlands.

Consideration	Rationale for Implementing Intensive Management
Likelihood of Success	High likelihood of success in reducing Gypsy Moth larva or adult populations and/or reducing the likelihood and extent of tree defoliation.
Protection of Values	Protects values (e.g., economic, aesthetic, recreational) and minimizes the loss of value to the municipality and other landowners.
Nuisance	Reduces nuisance problems caused by the presence of Gypsy Moth larvae or adults.
Public Concern	Addresses public concern over the use and exposure to insecticides or other management tools.
Adverse Impacts	Minimizes adverse impacts on target and non-target areas/organisms.
Tree Health and Condition	Trees in good overall health and structural condition, and which would otherwise be expected to maintain this status independent of Gypsy Moth defoliation. Healthy trees may be able to withstand one or two consecutive major defoliations before intensive management is initiated. However, weakened trees are vulnerable to stresses (e.g., drought, fungus, insects).
Tree Susceptibility and Vulnerability	Highly susceptible and/or highly vulnerable but otherwise valuable trees. • Trees which may be more susceptible to Gypsy Moth (i.e., more likely to become infested) include host species, trees located in host-dominated stands (e.g., oak comprising more than 20% of forest stand), and even trees located on drier upland soils. • Trees which may be more vulnerable upon infestation (i.e., less able to withstand its adverse effects) include trees in poor health or trees which have been repeatedly defoliated.
Tree Size	Protect healthy larger trees (additional ecosystem benefits) against infestation and defoliation.
Tree Value	Large-stature trees or those located in high-exposure areas where aesthetics are important.
Tree Species	Some tree species, such as Oaks, are preferred by Gypsy Moths and may be more susceptible to continued impacts. Some tree species, such as pines and other conifers, are less resistant to multiple years of defoliation than hardwoods.
Tree Clusters/Groupings	Some trees do not meet the threshold for treatment but exist within a cluster or grouping of other trees that do exceed the threshold for treatment. In order to address the stand/population holistically, treatment of trees with adjacent and overlapping canopies may be beneficial.

7.2 Integrated Pest Management

The first approach in managing invasive forest insect pests is preventing their arrival into an area. If this fails, then eradication becomes the next approach in order to prevent them from becoming established. Finally, if the invasive species has arrived and is established, the only remaining tactic is to slow its spread within the area.

For federally regulated pests, all three approaches are under the jurisdiction of the federal government and are carried out on the national scale by the CFIA, with direction from the federal Canadian Plant Protection Act S.C. 1990, c. 22.

Chemical management of Emerald Ash Borer. Signs may ensure that the process is not distubed by the public. Photo by CVC.

The current list of forest insect pests that are regulated by CFIA are those that are listed under Schedule I and Schedule II of the Plant Protection Regulations (SOR/95-212) issued under the Plant Protection Act S.C. 1990, c. 22. Municipalities are mandated to support pest eradication programs led by the CFIA, although from time to time local populations of other pests (not on this list) may also be considered for eradication. In the City of Mississauga, each of the three current priority invasive insect pests identified under the ISMP is regulated by the CFIA.

In the majority of cases, awareness of the presence of an invasive insect is reached after the pest has arrived and eradication is not possible. At this stage, control options for mitigating the negative effects of these pests can only be achieved through an integrated approach to reduce their populations to an acceptable level. Integrated Pest Management (IPM) is designed to keep pest populations below the threshold level at which they have significant economic and ecological impact.

The methods used to eradicate or manage pest species can vary, depending on the species, degree of infestation, available resources, and surrounding environment (e.g., proximity to human habitation, wetlands, and other sensitive ecosystems). Regulation under these criteria remains with the federal (Pest Control Products Act S.C. 2002, c. 28) and the provincial (Pesticides Act R.S.O. 1990, c. P.11 or Forestry Act R.S.C. 1985, c. F-30) governments. Methods to manage or eradicate tree pests may include:

- Silvicultural
  - planting diverse, native tree species
  - trees of different ages and genetic diversity (planting stocks of different clones or provenances)
  - cutting or thinning woodlands/ravines
- Mechanical

  - barriers (e.g., barrier bands, burlap bands)
  - selective pruning
  - removing or amending duff layer

- Biological
  - plant resistance (planting species that are resistant to known pests, e.g. Butternut trees that are genetically resistant to canker[4])
  - conservation, introduction, and/or augmentation of natural enemies including native and/or non-native (use of non-native natural enemies is identified as classical biological control and is regulated by the CFIA)

- Chemical
  - available synthetic insecticides, fungicides or herbicides regulated federally by the Pest Management Regulatory Agency (PMRA)
  - naturally-derived pesticides (e.g., pyrethrums, azadirachtin)
  - synthetic pheromones regulated by the PMRA

4 Ontario's Invasive Species Awareness Program

IPM includes two or more of the above components and control options. It is the most desirable approach and provides a proactive approach to prevent pests from reaching damaging levels. Recommended actions are developed based on a comprehensive risk-benefit evaluation of the pest, its impact, and costs of control.

If pests are unregulated, then the municipality will have sole responsibility for their management. Monitoring is a key component in this strategy and serves to identify potential pest problems in advance of their requiring action. On-going monitoring programs should be in place and knowledge of potentially new pests maintained.

8.0 Management in Response to Tree Removal Resulting from Emerald Ash Borer Infestation

Due to EAB infestation in natural areas throughout the City, Ash trees are being removed in response to hazardous conditions. These tree removals result in increased light and disturbed soil, conditions which may favour growth and propagation of invasive plant species. The impact to natural area ecological integrity resulting from Ash tree removals depends on many factors, including the extent and density of tree removals and the presence of priority invasive plant species.

This information can be used to prioritize locations for invasive species management, given the potential increased establishment and spread under the favourable growth conditions (i.e. disturbed area with increased light and available resources).

8.1 Invasive Flora Control Methods in Response to EAB

Following the identification and characterization of invasive flora at an Ash removal location, management strategies should be developed in line with the recommendations in Section 6.3. For example, during Ash tree removal, invasive shrubs (e.g., Buckthorn, non-native Honeysuckle) can be cut and treated when it is possible to include this in a contractor's work order. The essential component to this example is the treatment of cut stumps with a herbicide (e.g., Glyphosate or Triclopyr) to prevent re-sprouting; otherwise the invasive species will grow back even denser.

It is important to note that some management strategies for invasive species may result in harm to existing native species that also stand to benefit from the canopy openings. Care should be taken to select management techniques that target invasive species while minimizing impacts to native vegetation and allowing these species the opportunity to succeed within the newly formed gaps.

8.2 Site Rehabilitation and Revegetation

In the event that invasive species were not documented during surveys in the area targeted for Ash tree removal, pro-active revegetation with native species (i.e., restoration) of a site impacted by extensive Ash tree removal should be completed. Even in the absence of visual evidence of invasive species, the disturbance to the area would favour the regeneration of non-native flora, in some cases invasive plants, that are better adapted to colonize a disturbed site than native species. Under the criteria developed within this report, Refer to Section 6.4.2 and Table 11 in Section 6.2.1 for further guidance.

Where Ash tree removals are extensive resulting in disturbance to the soil and major changes to the microclimatic conditions (e.g., more light and wind, drier soils), it is recommended that efforts be made to prevent the colonization of non-native and

invasive plants, including invasive species, particularly in areas where they had been documented previously in the understory. This can include spreading a thick layer of mulch (>7.5 cm) that will suppress the germination of seeds in the soil, and planting a mix of native trees and shrubs. Mulch could be substituted with wood chip resulting from tree removals (i.e., chip can be left on site). However, as the mulch breaks down over time, the germination of seeds dormant in the soil may occur resulting in an understory dominated by non-native plants. Mulching may also change soil properties and smother existing native vegetation, if it is not avoided. Alternatively, a native seed mix can be sown (e.g. broadcast) and/or the area be planted with native flora including a mix of tree seedlings, shrubs, herbaceous plants and graminoids, that will regenerate in this area and take hold before non-native vegetation becomes established. Native flora should be selected based on existing community composition, where rehabilitation of the area to maintain ecosystem function would include species known to out-compete invasive species (see Appendix 6 for a list of suitable native plants).

8.3 Monitoring

As discussed in Section 6, following the initial characterization of the status of invasive species associated with areas where Ash removals are anticipated (i.e. baseline inventory), biannual monitoring is recommended in order to evaluate the effectiveness of control and restoration strategies and to enable EDRR to any changes that are considered to be disadvantageous to the recovery of the area where Ash tree removals had occurred (e.g., deer browse of planted trees and shrubs) and the ecological integrity of the surrounding natural area (e.g., changes in microclimate of adjacent vegetation community may negatively impact native flora and/or encourage growth and germination of non-native species).

9.0 Invasive Species Biomass Disposal

Following invasive species management practices that involve the removal of invasive species, consideration must be made for the appropriate disposal of the accumulated plant biomass. Invasive species can be spread to other areas if not disposed of properly (e.g., wood containing EAB larvae, seeds from pulled Garlic Mustard). In addition, some invasive plants contain irritants and noxious chemicals that can be harmful to human health if not disposed of properly. Therefore, techniques for safe handling and disposal of invasive plant biomass are essential to decrease the spread of invasive species to unintended areas as well as address human health and safety concerns.

Garlic Mustard being pulled and disposed of in bags to be taken off-site. Photo by CVC.

9.1 Invasive Plants

Biomass disposal techniques recommended under this ISMP&IS are those that are considered to be most efficient, effective, and simple enough for volunteer events. Some of these approaches include: solarization, chipping, decomposing, and composting. Table 25 provides information on each of the recommended techniques. A number of other biomass disposal techniques (e.g., tarping and drying, flooding, burning, burring) can be used in the management of invasive species; however, at this time they are not considered to be the most advantageous techniques for use in the execution of the City's objectives under the ISMP&IS and are therefore not discussed further in this document. Biomass disposal methods that involve leaving material on site must be monitored for re-sprouting within one year after disposal. This provides the opportunity to implement additional management should there be any re-sprouting. The length of time that materials will be left on site will vary based on the time of year.

Further to Table 25, Figures 4 and 5 provide decision matrices that allow the user to determine the most appropriate biomass disposal technique based on the vegetation type (woody or non-woody) and reproduction type (seed or seed and plant fragment). It is important to distinguish between these two vegetation types because they allow for different types of biomass disposal. For example, woody vegetation can be chipped, and herbaceous material can be solarized, but not vice versa. Reproduction type is an important distinguishing factor for biomass disposal, as the

Table 25. Recommended invasive plant biomass disposal techniques.

Biomass Disposal Technique	Target Groups	Description	Disposal Method	Leave Materials On or Off Site	Comments
Solarization	Herbaceous plants	Place plants entirely into heavy black bags (contractor grade) Label bags as necessary and/or assign a designated area	Leave bags in the sun for several weeks (placing on dark pavement has the best effect)	Either; there is no concern of spread due to containment in bags Depending on volume, the City can handle storage of smaller quantities.	Consider alternative options when facing larger quantities of material. Disposal of inert materials in municipal waste facility Seeds may remain viable under 50°C[1]
Chipping	Woody plants that don't reproduce vegetatively	Chip woody material	Spread chipped woody material (eg. on trails), in area where large (>10m2) amount of invasive species have been removed to suppress future regrowth, and/or pile on site for future use	Depends on stage of reproduction: • if chipped after fruit/seed production, leave chips on site. Chipped materials should be spread only in areas from which they were removed • if chipped before fruit/seed production, chips can be moved off site, or spread outside of invasive species area • if chipped material potentially contains an invasive insect, leave chips on site	If smothering of native species is a concern, then depth of mulch should not exceed four (4) cm
Decomposing	Variety; method depends on reproduction type	Prior to fruit/seed: • seedlings and small plants: leave material on ground with roots exposed • larger plants: pile material After fruit/seed: pile and cover If plant reproduces vegetatively: pile	Leave in place to decompose across area where invasive species were removed; pile or scatter	Decision to leave materials on site should be made on a site basis. Where it is preferable to leave materials on-site, it may not be feasible to leave materials (e.g., proximity to public, trails, visual appearance)	Consider a minimum distance when allowing materials to decompose on site (e.g., minimum 30 m from the edge of the natural area) Remove plant materials from site for areas within 30m of trail Cut down brush piles to minimal size (e .g., do not exceed 0.5m, or 1.0m in length/width for exposed piles) in height for areas >30 m from trail and leave on site Leave logs on site to rot, spread out in long lengths Avoid smothering desirable herbaceous vegetation
Composting	Herbaceous plants	Plants collected into black bags (contractor grade)	Disposal of inert materials in municipal waste facility	Off-site	Minimum requirements for in-vessel composting discussed in Section 9.2

1 Dahlquist et al., 2007

Figure 4. Decision matrix for biomass disposal of woody invasive plants.

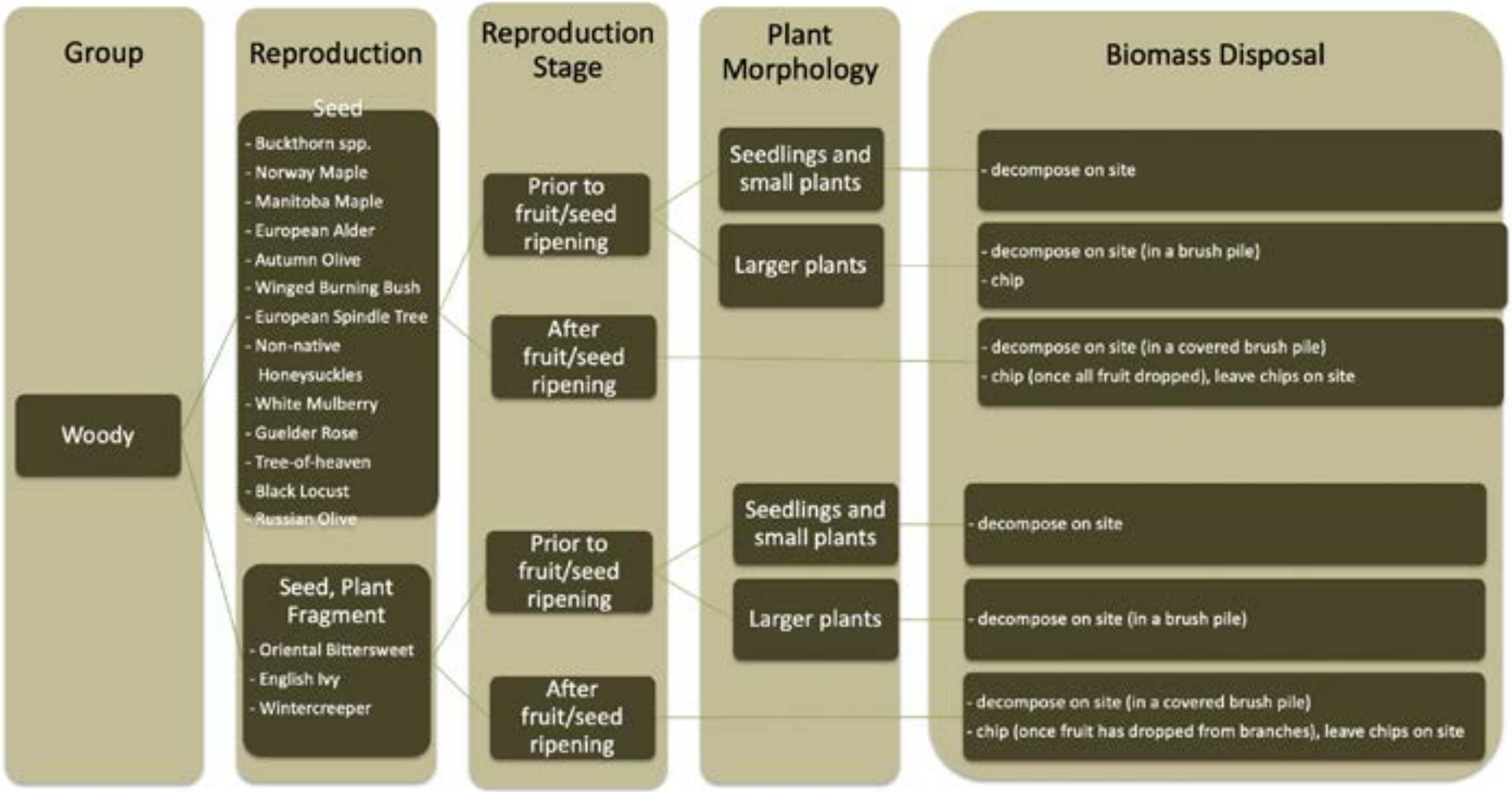
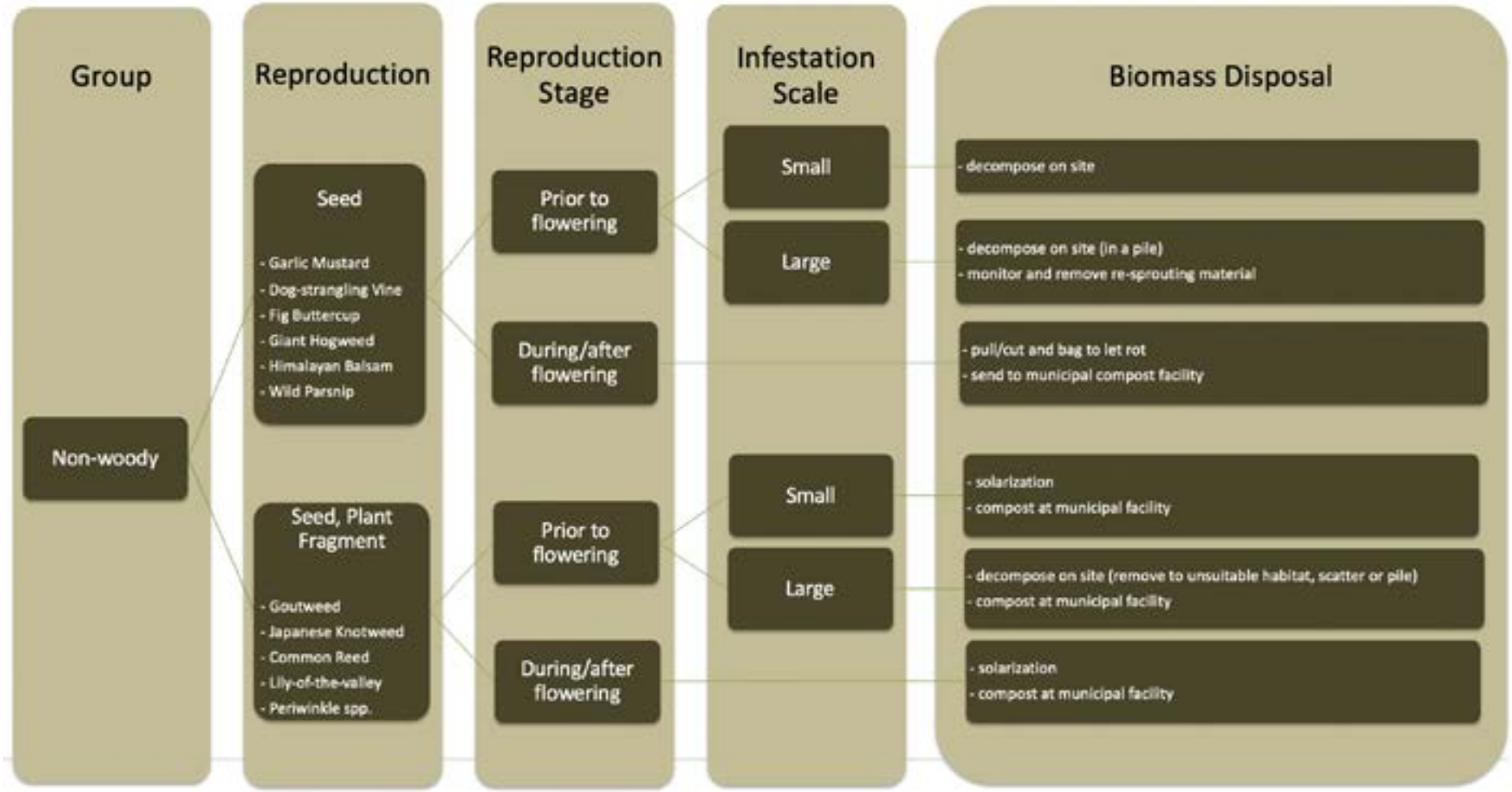


Figure 5. Decision matrix for biomass disposal of non-woody invasive plants.



disposal type must account for the potential for plants to re-sprout or spread after being removed from an area. Location of biomass disposal is also detailed in Figures 4 and 5. Options are on- or off-site. On-site is defined as the area where the invasive species were removed. Invasive species biomass is not meant to be placed elsewhere in the natural areas – restricting the placement of invasive species biomass is important in preventing potential spread. Off-site could include another impacted natural area or a storage facility. In the case of excess biomass, material can be stored off-site, outside and away from natural features to prevent potential spread.

When considering transferring plant biomass to off-site locations, it is important to be aware of any restrictions on disposal methods. For example, currently, the CFIA has regulated quarantine within the regional area of Malton which imposes restrictions on the movement of any nursery stock, trees, logs, lumber, wood, wood chips, and bark chips from certain deciduous trees and firewood of all species (Region of Peel, 2017). Movement of these items out of the regulated area is prohibited.

9.2 Composting Invasive Plant Materials in the City of Mississauga

The Ontario Compost Quality Standards (Ontario Ministry of the Environment, 2012) identifies temperature requirements for compost in order to reduce the risk from adverse health effects from pathogens. These standards require compost to maintain a minimum temperature of 55 °C for a minimum number of days. From an ecological perspective, it is necessary to ensure that the composting procedure results in an output of biologically inert invasive plant material.

A number of studies have investigated the validity of composting invasive species biomass in order to offset the costs of invasive species removal. The major concern with this practice is the risk that the final composted materials may contain viable seeds of invasive species if sufficient conditions have not been met throughout the composting process. Generally, the literature is in agreement that a temperature of 55-69 °C is required to produce biologically inert materials; however, it is important to note that the amount of time required to render a seed inviable varies between species (Tompkins et al., 1998; Nishida et al., 1998; Brito et al., 2013; Van Rossum and Renz, 2015; Schmiedel et al., 2016). For example, seeds from Garlic Mustard were 100% inert after seven days at 55 °C, but Buckthorn seeds required 15 days (Van Rossum and Renz, 2015). Tompkins et al. (1998) found that a four week composting period (at 55-65 °C) was effective for 12 invasive plant species. Higher temperatures and longer length of time increase the probability of all seeds and pathogens becoming inert (Van Rossum and Renz, 2015). Since some species (such as Japanese Knotweed) require multiple months of composting to become inert (Brito et al, 2013), only species that have been proven to become 100% inert after a composting process should be disposed of using this method and care should be taken to ensure that the appropriate duration of composting is used.

The Region of Peel composting facilities are managed by Biorem at the Caledon Sanitary Landfill Composting Facility. This facility uses the in-vessel method of composting whereby the material remains in the vessel for seven to ten days with three days where temperatures reach over 55 °C. After the initial seven to ten days of in-vessel composting, a curing process is undergone for six months. Based on the status and recommendations under the current literature, the method for composting employed by the Region of Peel is not considered sufficient to render the seeds of invasive plant material biologically inert.

9.3 Material Containing Invasive Insects

Tree removals due to invasive insect infestation can result in a large amount of biomass that requires specialized disposal. Generally, reutilizing suitable cut trees as timber is the preferred method; however, many trees will be unsuitable for reutilization due to size

or condition of the bole. As such, most material will have to be disposed of differently. It is recommended that tree material left on site be chipped into pieces of 1.5 cm or less in size. Material left on site, and not chipped, has the potential to harbour invasive insects. The maximum chip size of 1.5 cm has been found to ensure that no insects survive. This chip size comes from the ALHB regulatory guidelines (Canadian Food Inspection Agency, 2014).

Slightly larger 2.5 cm chips have been found to be sufficient for EAB infested material (McCullough et. al., 2007); however, to be consistent and cautious, 1.5 cm is recommended as the maximum chip size for all material infested with invasive insects. Biomass disposal methods for woody material infested with invasive insects are provided in Table 26.

Table 26. Biomass disposal for material resulting from invasive insect infestation.

Invasive Insect	Restrictions on Movement Material	Biomass Disposal	
		On-site	Off-site
Emerald Ash Borer	within Southern Ontario*	Leave tree to decompose Chip for trail surfacing or invasive species management (mulching)	Excess material moved off-site
Asian Long-horned Beetle	within regulated area**		
Gypsy Moth	within Southern Ontario		

* Exception: Ash trees cut due to EAB infestation within ALHB regulated area must stay within the ALHB regulated area (even though Ash species are not a host species for ALHB).

** As of June 2020 the regulated area for ALHB in the vicinity of Malton is no longer in place.

10.0 Costing and Staffing Requirements

The costs and staffing requirements associated with invasive species management can vary greatly depending on the invasive species of interest, the size of the area, and method employed to manage the species of interest, and the amount of restoration proposed. Tables 27 and 28 provide a high level costing scheme for each component of implementation of the invasive species management plan. Staffing requirements and opportunities to engage volunteers have been considered in the costing scheme. Costing schemes have been estimated based on 2016 market values, and costing requirements will be refined based on real world examples from ISMP&IS implementation at demonstration sites.

Table 27. Costing and staffing requirements for invasive plant control/removal.

Work Item	Productivity/Day	Staffing Requirements/Day	Cost/Day (Labour and Equipment)	Cost/Hectare	Notes
Cut & treat Buckthorn sp. & shrubs, chip & remove materials, leave stumps	Dense growth (10 stems/ m^2) = 0.09 ha Light/ scattered growth (1 stem/2 m^2) = 0.4 ha	4 people	$2,920	$32,400 dense $7,300 light	
Cut & treat Buckthorn sp. & shrubs, pile materials on site, leave stumps	Dense growth (10 stems/ m^2) = 0.09 ha Light/scattered growth (1 stem/ $2m^2$) = 0.4ha	4 people	$1,920	$21,300 dense $4,800 light	
Cut & treat Manitoba/Norway Maple/other tree species saplings/small trees & shrubs, chip & remove materials, leave stumps	Dense growth (10 stems/ m^2) = 0.09 ha Light/scattered growth (1 stem/2 m^2 with none in some places) = 0.4 ha	4 people	$2,920	$32,400 dense $7,300 light	
Cut & treat Manitoba/Norway Maple/other tree species saplings/small trees & shrubs, pile materials on site	Dense growth (10 stems/ m^2) = 0.09 ha Light/scattered growth (1 stem/2 m^2 with none in some places) = 0.4 ha	4 people	$1,920	$10,700 dense $4,800 light	
Cut & treat Manitoba/Norway Maple/other tree species trees <30cm DBH in natural forest, pile brush materials on site, leave logs & stumps	0.25 ha	2 people	$1,920	$7,680	If large trees >30cm DBH present they may need to be taken down using machines or climbers, costs will vary widely. Girdling may be an option.
Cut & treat Manitoba/Norway Maple/other tree species trees <30cm DBH in natural forest, remove brush & logs	0.25 ha	2 people	$1,920	$7,680	Trees must be within reach of crane (10-15m from hard surface trail).
	0.5 ha (with crane truck)	3 people	$3,400	$6,800	

Work Item	Productivity/Day	Staffing Requirements/Day	Cost/Day (Labour and Equipment)	Cost/Hectare	Notes
Spray (herbicide) Common Reed monoculture in open dry marsh, leave dead materials on site	0.5 ha	4 people	$1,600	$3,200	Removal of dead materials would need to be priced if needed, or burn dry material on site.
Wick (herbicide) Common Reed in open dry marsh mixed with native plants, leave dead materials on site	0.25 ha (1 stem/m^2 density)	4 people	$1,600	$6,400	
Spray (herbicide) Dog-Strangling Vine monoculture	0.4 ha	2 people	$800	$2,000	
Wick (herbicide) Dog-Strangling Vine mixed with natives	0.25 ha	2 people	$800	$3,200	
Spray (herbicide) Garlic Mustard rosettes in spring	0.4 ha	2 people	$800	$2,000	
Pull garlic mustard plants in May, remove from site (bag)	0.3 ha	2 people	$800	$2,400	Can be done by volunteers under supervision.
Clear entire site for planting (machine grubbing & tilling sapling woody plants and root crowns)	0.4-1.0 ha	5 people	$2,000	$2,000-$5,000	Sites must be relatively flat, stumps must be <20cm diameter at ground level.
Re-cut and treat stumps of cut trees or shrubs after cutting	0.25 ha	2 people	$960	$3,840	Re-cutting stumps left 15cm tall by removal crew, 1 day to 1 year after initial cutting.
Dig and treat regrowth of Japanese Knotweed	200 m^2	2 people - initial effort	$800	$40,000	May require several spray treatments to be effective. If site is open field may be best to spray then till entire field with farm equipment several times.
		2 people - retreat	$600/yr	$30,000	
Girdle trees without herbicide treatment	60 trees @ 30 cm dbh	1 person	$400	$5,000	Trees less than 15cm diameter at base should be cut and stumps treated.

All costs are estimates using 2016 typical market costs; HST is extra.

Table 28. Costing and staffing requirements for restoration plantings.

Restoration Planting Type	Size of Stock/Method	Cost of Plant, Mulch and Labour/Plant	Recommended Density	Cost/Area	Notes
Tree (large)	Bare root, container grown, 5-7 gallon pot	$40-50	1 plant/$10m^2$	$2,000-2,500/0.5 ha	Volunteers reduce labour costs by $10/tree
Tree (small)	1 gallon/whip	$30-40	1 plant/$10m^2$	$1,500-2,000/0.5 ha	
Shrub (large)	Bare root, container grown, 3-5 gallon pot	$20-30	2 plants/$10m^2$	$2,000-3,000/0.5 ha	
Shrub (small)	1 gallon/whip	$15-20	4 plants/$10m^2$	$3,000-4,000/0.5 ha	
Herbaceous and Graminoids	Plugs and pots	$8-10	10/m^2	$80-100/$m^2$	Volunteers reduce labour by $1.25/plant
	Seeding (hand)	N/A	N/A	$500/0.5 ha	Volunteers not recommended for seeding

All costs are estimates using 2016 typical market values.

11.0 Grant/Funding Opportunities

Resources and organizations exist that provide grants/funding that will allow the City to better allocate resources and improve the ability to execute the ISMP&IS. Further to the funding resources available to the City, many of the grant/funding opportunities can be spearheaded by local community/neighbourhood organizations that are seeking opportunities to undertake invasive species management initiatives in their neighbourhoods (e.g., Trillium Foundation).

Given that funding opportunities and organizations may change over the lifespan of this document (through 2033), initiating a review of current opportunities should be tied in to the progress reports completed every four years at a minimum.

Appendix 8 summarizes current funding sources that may support invasive species management projects in the City. While some of these sources may not appear to be strictly associated with invasive species (e.g., Habitat Stewardship Program for Species at Risk, Species at Risk Stewardship Fund), they may allow for projects that achieve the program goals by means of invasive species management.

Funding by a private organization permitted for the completion of a restoration plan and purchase of plant materials for restoration of this conifer plantation. Planting was completed by volunteers. Photo by Sal Spitale.

12.0 Demonstration Sites and Implementation of the ISMP&IS

The ISMP&IS has taken into consideration existing programs, resources, knowledge of the City's natural areas, and input from various City departments (e.g., Parks, Forestry & Environment) and stakeholders, with the goal of managing terrestrial invasive species in an economically efficient manner while enhancing native biodiversity and overall ecological integrity of the City's natural areas.

While the ISMP&IS provides direction for making decisions and resource allocation, it is important to 'test' the ISMP&IS at a smaller scale in order to demonstrate how actions of the ISMP&IS will be implemented, identify any efficiencies, and to improve the approach to invasive species management. Therefore, the ISMP&IS will begin with two demonstration sites.

Through discussions with City staff and evaluating practical considerations, two demonstration sites have been selected. The selection of the demonstration sites was based on the following objectives:

- Educate and interest public/residents, and
- Test and assess ISMP&IS approach and methods (opportunity for monitoring and adaptive management).

Considerations for demonstration sites:

- Accessibility (e.g., for management and/or public access)
- Special demands (e.g., high profile, cultural/public value)
- Feasible (e.g., realistic expectation of success/achievable, short-term attainable)
- Capacity to carry out project (e.g., resources to complete project fully)
- Representativeness of priority site characteristics
- High ecological integrity

The following characteristics are necessary for selection of demonstration sites:

- City-owned land
- Easy access for vehicles and equipment
- Relatively flat topography (i.e., no steep valley slopes) for ease of access for volunteers
- High profile site
- Holds public value
- Ability to focus on sites or vegetation communities that have potential for success (i.e. do not focus on areas dominated by non-native and/or invasive species, such as cultural meadows)
- Small sized natural area or a discrete area within a larger natural area
- Potential to combine management with other activities on site
- Variety of management needs (e.g., more than one invasive

species, vegetation community and other impacts such as Ash tree removal)

- Variety of adjacent land uses
- Variety of priority invasive species documented
- Fair or good condition (according to NAS surveys)
- Significant natural area classification

Based on the above listed rationale, considerations, and characteristics, **Windrush Woods (ME8)** and **Creditview Wetlands Park (EC13)** are identified as demonstration sites for the ISMP&IS. The characteristics of each natural area are outlined in Table 29. Note that both of these natural areas contain a water feature (creek or wetland) allowing for a test of techniques in proximity to aquatic features.

12.1 Implementation of the ISMP&IS

The implementation of invasive species management will begin with the demonstration sites and should be guided by the direction provided for in this Plan. As such, the following steps are suggested in order to implement the ISMP&IS at the demonstration sites:

1. Complete a baseline inventory and mapping of invasive flora to document species, locations, and extent of populations (Section 6.1).
2. Identify any ongoing or potential invasive fauna monitoring and management plans (e.g., EAB tree removal) (Sections 7 and 8).
3. Develop preliminary costs/budget for managing invasive flora (Section 10).
4. Identify potential grant/funding opportunities (Section 11).
5. Identify opportunities for engagement, partnership with stakeholders, involvement with community groups, local schools, and the public at large (Section 4).
6. Form internal working group to review existing available budget and resources (e.g., staff resources, community groups), revisit goals and objectives, and to decide on order of active management and priority areas/species (Section 3). In discussion with internal working group determine which components of the invasive species management will be completed by volunteers and City staff, and where contractors will be required to address management actions (e.g., herbicide treatment, tree removal, sourcing and planting of native plants and sowing of native seeds). Discuss and determine how/where biomass will be disposed (Section 9).
7. Implement communication plan (Section 5). Hold workshops and volunteer activities as part of communication, public outreach and engagement.
8. Following invasive plant management by volunteers, staff and/or contractors, implement monitoring plan (Section 6).
9. Track progress of implementation of ISMP&IS on demonstration sites (Section 2.3).

12.2 Overview of the ISMP&IS

The City of Mississauga recognizes the critical role that the Natural Heritage System and Urban Forest provide in sustaining the City's green infrastructure. Due to the widespread nature of invasive species in the City's natural areas and the threat invasive species pose to the ecological integrity of the City's Natural Heritage System and the Urban Forest canopy, the City of Mississauga has identified the need to develop a comprehensive ISMP&IS that balances the ecological, economic, and social vision for the City while working towards better protecting and enhancing the City's natural resources.

The ISMP&IS has been developed with the goal of providing an organized targeted approach to managing terrestrial invasive species in a fiscally responsible manner while enhancing native biodiversity and ecological integrity within the City's natural areas. The following components of the City's approach to invasive species have been developed through this plan:

Objectives, Targets and Timeline
Objectives and targets have been established (Section 2) in order to track the success of the ISMP&IS and allow for regular reporting and an adaptive management approach that will inform future decision-making. To that end, the ISMP&IS should be considered a living document that is intended to allow for proactive management in order to respond to changes in existing conditions and address new threats by invasive species to the ecological integrity of the City's natural areas. Fully funded, the expected timeline would be 5 years per management stage, totalling 15 years, however completion of the plan may take longer depending on the availability of funding and staff resources.

Resource Allocation
The ISMP&IS has provided an approach to assess available resources and determine how to maximize resources and focus management efforts in priority sites and locations within natural areas. An internal working group would review available resources and inform decisions on where to allocate resources.

Opportunities for Engagement
The ISMP&IS recognizes the valuable knowledge, expertise and resources the City's partners, stakeholders and community can contribute to the implementation of this Plan.

Community engagement, inter- and intra-specific collaboration, and developing partnerships will improve the effectiveness of the ISMP&IS and help the City achieve its goals to improve the ecological integrity of the City's natural areas. The ISMP&IS has identified potential partners and stakeholders that can work with the City towards achieving its goals.

Concept Communications Strategy
The effective communication of the ISMP&IS is vital to ensuring the effective and successful implementation of this Plan. The concept communications strategy identifies key stakeholders/ partners for a given area, defines clear, measurable communication objectives, includes key messages and information for dissemination, and recommends an approach to measure and monitor the communication activities.

Management of Invasive Flora and Fauna
The ISMP&IS recognizes that successful management of invasive species requires knowledge of existing populations, targeted and specific management tactics, tracking of management activities, and continued monitoring of existing and controlled populations. Inventory and monitoring methodology with suggested field datasheets and tracking forms have been provided to guide the management of invasive flora and fauna. Specific direction has also been provided in order to make decisions on where to manage invasive plant populations and control techniques, including using active restoration as a means of control and improving natural area ecological integrity. Recommendations have also been provided for managing natural areas impacted by Ash tree removal resulting from EAB infestation.

The ISMP&IS has integrated invasive insect management plans and activities currently being undertaken by the City. Additional information has been provided for regarding insects that have historically impacted the Urban Canopy as well as for species that in time, are likely to spread into the City.

Budget and Staffing Requirements
Invasive species management will require City staff and funding. The ISMP&IS has provided approximate costs to implement invasive plant control depending on the species, control method, extent of population and involvement of volunteers. Approximate

numbers of staff to implement management activities has also been provided. The ISMP&IS has provided a list of potential grant/ funding opportunities.

Tracking and Reporting

Tracking of the ISMP&IS is key to ensuring resources are being optimized and City staff can account for all management activities, while adapting management decisions to changes in priority species and sites. As part of tracking the development of the ISMP&IS, it is recommended that a progress report be completed every four years.

Demonstration Sites

The ISMP&IS is a significant undertaking requiring a thoughtfully managed and organized implementation. In order to ensure the approach to management is effective and efficiently uses City's resources, two demonstration sites have been selected. These demonstration sites will be used to showcase the implementation of the Plan and educate the public about the impact of invasive species on the City's natural areas and the benefit of proactive management. Tracking and reporting on the implementation of the ISMP&IS at the demonstration sites will allow the City to evaluate the Plan and make changes that can be brought forward to the implementation of the Plan in the priority natural areas.

Table 29. Considerations and characteristics of demonstration sites.

Considerations	Characteristics	Demonstration Sites	
		Windrush Woods (ME8)	Creditview Wetlands (EC13)
Accessibility	City-owned land	✓	✓
	Easy access for vehicles and equipment	Vehicle access along trails	Vehicle access from Willowvale Fields parking lot and manicured area
	Relatively flat topography (i.e. no steep valley slopes) for ease of access for volunteers and to avoid potential erosion issues	✓	✓
Special demands	High profile, but not priority site	✓	✓
	Cultural/public value	Recreational trails	Wetland viewing platform
Feasible	Ability to focus on sites or vegetation communities that have potential for success	✓	✓
Short-term attainable	Small sized natural area or a discrete area within a larger natural area	5.84 ha	5.18 ha
Capacity to carry out project	Potential to combine management with other activities on site	Existing management programs (restoration planting, Ash tree removal)	Existing management programs (Ash tree removal)
Representativeness	Variety of adjacent land uses	• Residential • School • Manicured Park • Railway corridor	• Residential • School • Manicured Park
	Variety of challenges (e.g., more than one issue/ community type)	• Edge effects • Designated BMX Circuit	• Edge effects • Change in site hydrology • Dense and satellite invasive species populations • Trampling and trail creation
	Variety of priority invasive species documented	• European Buckthorn • Garlic Mustard • Tatarian Honeysuckle • Norway Maple • Periwinkle	• European Buckthorn • Garlic Mustard • Tatarian Honeysuckle • Manitoba Maple • Guelder Rose • Black Locust • Russian Olive
Ecological integrity	Fair to excellent condition	Fair	Excellent
	Significant Natural Area classification	✓	✓

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